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SVIC NOTES

Changes in Engineering Curricula?

Many short courses are available today that cover a wide range of subjects in shock and vibration. These courses are sponsored by various organizations, including professional societies, small educational institutes, academic institutions, and manufacturers. Considering the wide range of subjects covered one might ask the question, "Are there any topics or courses in shock and vibration that should be added to the engineering curriculum in universities?" There are three possibilities which I would suggest, (1) modal testing and analysis, (2) damping and (3) mechanical shock.

Modal testing and analysis is now in such common usage that few would question its appearance in the course catalog of an engineering school.

Damping hasn't yet received the same publicity as modal testing but it is nonetheless an important subject. A full course might include the topics of vibration and shock isolators, active control, viscoelastic material properties, noise reduction and layered damping treatments. If more training were given in this subject area then more vibration problems would be eliminated in the design stage before it becomes necessary to develop an expensive fix in the production stage.

My third suggestion, mechanical shock, is admittedly a more specialized subject often associated with military applications; but there are nonmilitary shocks such as earthquakes, pyrotechnic shock, air blasts and metal-to-metal impact. It would probably be alright if an expanded coverage of mechanical shock were included in a larger course on structural dynamics. Suggested topics for inclusion would be the shock response spectra, shock sources, specialized solution techniques, instrumentation, design methods, data reduction and interpretation.

Other more specialized topics in the subject area of shock and vibration are currently receiving a great deal of interest but they don't yet warrant a full semester university course. This includes many specialized topics in machinery vibration, engineering instrumentation, digital data analysis, fluid-structure interaction, control systems, reliability, structural integrity and penetration mechanics.

Short courses should be thought of as a possible test bed for the development of full academic level courses. If a subject such as modal testing and analysis is taught for many years by many organizations, then it is a good candidate for inclusion in a university curriculum. Those short courses that don't receive much interest or enrollment will automatically be eliminated from further consideration.

JGS

EDITORS RATTLE SPACE

ON THE BENEFITS OF TECHNICAL MEETING ATTENDANCE

The question of who attends technical meetings came up when it appeared that the majority of attenders at the 56th Shock and Vibration Symposium were experienced engineers. Perhaps the better question should be -- who should be attending technical meetings? It is necessary that those who have written papers for presentation at a meeting be the first to go. However, in view of budgetary constraints, who benefits the most from these meetings and what benefits the company the most? Should the senior engineer or manager be given right of first refusal as a reward for service or should the young engineer go because of technical growth? Let's examine some of the reasons people go to meetings.

The principal purpose for attendance at technical meetings is to keep up with current technology. Meetings held today fill other functions which help the engineer to perform his or her daily duties in a more efficient manner. More tutorial sessions and workshops on current technology are provided at current meetings. These sessions benefit both new and experienced engineers. They provide both directed knowledge and exposure to practical experience. Again, both types of session benefit the experienced and new engineer. Finally, the informed interaction among participants provides the exchange of much technology. Some believe this to be the most beneficial part of the meeting process. Because of their long term friendships, exposure to previous meetings, and general technology experience, the experienced engineer probably benefits most from this informal exchange. In any event any person attending a meeting should return with a wealth of information and ideas for implementation. The change of pace provided by the meeting incites new enthusiasm for the job which is approached with new ideas and techniques. Thus the meeting not only is a mechanism for exchange of technology but also provides a revival of spirit.

With all this in mind who should the company send to the meeting? In view of the potential benefits it appears to me that a company, university, or government facility would want to send each engineer to one meeting per year. It should be considered to be part of the cost of maintaining a person on the staff -- the same as overhead and benefits. What good is it to have a person on the staff who is not trained and motivated to provide maximum efficiency. Even though travel is expensive, I believe it should not be looked at as an easy place to effect cost cutting measures. I believe in quality over quantity in this situation. It would be better to have less properly trained staff members for an efficient operation. Therefore it is hoped that more organizations will look at technical meeting attendance as a necessity rather than a costly perk given as a reward for long time service.

R.L.E.

RESEARCH ON DYNAMIC BEHAVIOR OF COMPOSITE AND SANDWICH PLATES — IV

C.W. Bert*

Abstract. This paper comprises a survey of the literature concerning the dynamic behavior of plate-type structural elements of either composite material or sandwich construction. Papers from mid-1982 through early 1985 and several references published late in 1981 are reviewed. Emphasis is given to transverse impact and subsequent damage, environmental aspects, linear and nonlinear analysis, and design (including aeroelastic tailoring). Configurations include rectangularly and cylindrically orthotropic, and laminated thin plates; thick plates; and sandwich plates.

Substantial progress has been made since the last survey of this topic [1] in 1982. A recent survey by Reddy [2] should be mentioned. Information sources referenced in the present survey are primarily journal or conference papers in the open literature. The following topics are not included: anisotropic-crystal plates and magnetoelastic effects.

RESPONSE TO LOCAL TRANSVERSE IMPACT

Research on this topic has considerably increased since the last survey primarily as a result of NASA research and NASA-sponsored research relative to low-velocity impact damage. Included are analyses of the dynamic contact process itself as well as experimental assessment of resulting damage by measurement of residual static strength.

Investigations of the dynamic contact process include the works of Lal [3-5], who made semi-empirical predictions of the coefficient of restitution for multilayer graphite-epoxy plates. Tan and Sun [6] studied the effect of static force-indentation relationships on impact response. Kunz [7] determined stress components on interlaminar surfaces as a function of position and time. Other investigations of the impact process and material response have been reported [8-13].

Kelkar and his co-workers [14] focused on large-deflection behavior for the case of quasi-isotropic-layup laminates. Chen and Sun [15, 16] considered the impact response of laminated plates already buckled due to static loading.

Evaluation and prediction of the extent of damage and the residual static strength of laminates have been investigated [17-27].

RESPONSE TO SPECIAL DYNAMIC LOADINGS

The dynamic stress concentration in composite strips, each containing a circular hole, has been studied in experiments in which the strips were subjected to high-velocity tensile loading [28]. Tani and Doki [29] analyzed the dynamic stability of cylindrically orthotropic annular-planform plates subjected to pulsating radial loading. Chonan [30] predicted analytically the response of a prestressed, thick, orthotropic plate strip to a moving line load. The bulging and failure of carbon-reinforced composite disks loaded by their own inertia have been studied [31], as has the response of a five-layer composite panel to shock-wave loading [32].

THERMAL, ACOUSTIC, AND AEROELASTIC EFFECTS

The vibrations of thermally stressed orthotropic plates of various planforms have been analyzed [33-37]. Sun and Chen [38]

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conducted a transient thermal stress analysis of graphite-epoxy laminates; they used a one-dimensional finite-difference heat-conduction code to predict the temperature distribution and a nine-node finite element for the resulting mechanical response.

Soovere [39] conducted theoretical and experimental investigations of the effect of acoustic/thermal environments on integrally stiffened graphite-epoxy panels for aircraft fuselage application. He pointed out that sonic-fatigue analysis methods are needed for the case of multimodal, nonlinear panel response.

Considerable progress has been made in the aeroelastic analysis and tailoring of composite plates. The application is in aircraft lifting surfaces, especially forward-swept wings. The three groups presently most active in this area are Hollowell and Dugundji [40] at MIT, Oyibo [41-44] at Fairchild Republic, and Weisshaar and Foist [45, 46] at Purdue.

LINEAR ANALYSES OF THIN COMPOSITE PLATES

Few structural components have actually been made in the form of cylindrically orthotropic (polar orthotropic) plates. The only instances known to the author are reinforcing bosses of filament-wound rocket-motor casings and filament-wound energy-storage flywheels. Nevertheless, analytical activity in this area remains strong. Cylindrically orthotropic plates of uniform thickness have been analyzed [47-52], as have those of varying thickness [53-56].

Rectilinearly orthotropic plates are easily constructed by parallel lamination of as many unidirectional layers as required to achieve a desired thickness. Investigations have been reported of orthotropic plates of rectangular planform [57-65], of effects of static in-plane forces on the vibration of such plates [66-67], and of the effect of parabolic thickness variation [68].

Special geometric complications in rectilinearly orthotropic plates that have recently been considered include circular planform [69-70], a polygonal planform [69], a circular segment [71], a trapezoidal segment [72], and a rectangular segment with a diagonally cut-off corner [73].

Preobrazhenskii and Shasalimov [74-76] analyzed the effects of the presence of circular holes and notches on free vibration of rectangular plates; Laura and Guiterrez [77] studied the effects of the presence of central inserts of rectangular or circular shape.

Lamination -- i.e., use of multiple layers at various orientation -- provides the composite-structures designer with considerable design versatility. At the same time, it provides the composite-structures analyst with considerable complexity, compared with isotropic materials or even with cylindrically or rectilinearly orthotropic plates. Various theoretical or experimental investigations have been reported [80-84]. Wearing and Patterson [85] investigated a vibrational technique to detect nondestructively the presence of delamination. Lin and co-workers [86] made one of the few recent theoretical and experimental investigations of vibration damping in laminated plates. Grosveld and Metcalf [87] conducted theoretical and experimental studies on both modal response and noise transmission in cross-ply and angle-ply plates.

LINEAR ANALYSES OF THICK COMPOSITE AND SANDWICH PLATES

Fiber-reinforced composite materials have low transverse (thickness direction) shear moduli relative to their in-plane moduli; plates constructed of such materials exhibit considerably more transverse shear deformation than homogeneous, isotropic plates of the same geometry, loading, and boundary conditions. Thus, with respect to transverse shear deformation, they have an effective thickness much thicker than their geometric thickness. Iyengar and Pandya [88] used Vlasov's method of initial functions to study thick, orthotropic rectangular plate vibration.

A number of theories for thick laminated plates have recently been introduced [89-94]. Reddy [95] used the finite element method to study the transient response of thick plates laminated of bimodular compos-

ite material; such material has different properties in tension and compression. Other shear-deformable finite-element models and analyses of thick, laminated plates are available [96-105].

The structural advantage of sandwich construction over conventional thin plates continues to make sandwich plates attractive. Free vibration of such panels of rectangular planform has been investigated [106-108]. Clarkson and Ranky [109] studied modal density, which is important in random excitation. Kolesnikov and Shalashilin [110] analyzed panels with trapezoidal planform. Soovere [111] concentrated on stiffened honeycomb-core panels with edges beveled on one side; such treatment is often used in practical structural applications of such panels.

Shock response of damped rectangular sandwich plates has been analyzed [112-113]. Wallace [114] investigated the acoustic fatigue life of honeycomb-core panels; Ohyoshi [115] treated wave propagation. The acoustic transmission loss of such panels has been predicted [116].

NONLINEAR DYNAMIC ANALYSES

When plates deflect more than approximately one-half the thickness of a plate, especially when the plates are constrained in the plane, they experience significant geometric nonlinearity. The nonlinearity is primarily due to the development of in-plane membrane stresses that effectively stiffen the plate. Nonlinear dynamic analyses of thin orthotropic plates are summarized in the table [117-131].

All of the relatively few analyses that have been published on nonlinear vibration of thick orthotropic plates [132-136] have been for the case of rectilinearly orthotropic material. Circular planform [132, 133] has been studied, as has the elliptic planform [134-136]. Thin, laminated plates undergoing large-amplitude vibrations have been investigated using Galerkin-type solutions [137-139] and finite-element solutions [140-143]. Thick, laminated plates have been investigated analytically [144] and with finite elements [145-150].

The first nonlinear solution for plates containing circular holes has been published [145, 146]. The nonlinear theory for thick, laminated plates introduced recently [151] has not yet been applied to solution of any specific nonlinear problem but has been applied to linear problems [94]. Double-wall sandwich panels undergoing large-amplitude vibration have been analyzed [152].

DESIGN

Despite numerous classical and numerical investigations of composite and sandwich plates, relatively few studies have been directed to the design of such plates. This is unfortunate because the payoff in composites is in design.

Most of these design studies, following the author's 1977 work [153], are directed toward design to maximize the fundamental frequency or to design for frequency constraints [154-160]. Others have been directed toward damped sandwich plates [161] or aeroelastic tailoring [43, 45, 46, 162].

TRENDS AND SUGGESTIONS FOR FUTURE RESEARCH

Notable trends in the research reviewed here include:

- Increased attention to the impact-damage problem
- Increased attention to geometric nonlinearity
- Continuing attention to transverse shear flexibility
- Continuing expansion in use of the finite-element method
- Too much attention to simple cylindrical orthotropy and rectangular orthotropy as opposed to more practical and efficient laminates

Analyses of Large-Amplitude Vibration of Thin Orthotropic Plates

Investigator	Ref.	Planform	Matl. Class*	Flexural B.C.'s	Remarks
Biswas	117	Rectangular	RO	Hinged	In-plane forces are present
Ohnabe et al	118	Solid circular	CO	Free	Thermoelastic waves, centrifugally loaded
Sathyamoorthy	119	Solid circular	RO	Clamped	Two methods of analysis
Banerjee	120	Square	RO	Clamped	Has an arbitrarily located concentrated mass attached
Chaudhuri	121	Solid circular	CO**	Clamped	Pulse excitation
Nowinski	122	Solid circular	RO	Free	Stability of circumferential waves, centrifugally loaded
Sathyamoorthy	123	Solid circular	RO	Clamped	Multimode analysis
Nath & Jain	124	Annular circular	CO	Various	Step loading, axisymmetric response
Dumir et al Nath et al	125 126	Solid circular	CO	Elastically restrained	Transient loading
Sathyamoorthy	127	Elliptic	RO	Clamped	Multimode analysis
Shilkrut	128	Solid circular	CO	Various	Snapping instability
Dumir et al	129	Annular circular	CO	Various	Transient loading, axisymmetric response
Dumir et al	130	Annular circular with finite rigid circular mass	CO	Various	Transient loading, axisymmetric response
Ruei et al	131	Solid circular	CO	Nonuniform elastic restraint	Harmonic excitation

* The symbols CO and RO denote cylindrically orthotropic & rectangularly orthotropic.
** *The author thought he was treating the RO case.*

The author believes that the following aspects should be investigated more fully in the future:

More realistic material models, including nonlinear stress-strain relations and material damping

Analyses of geometrically nonlinear panel flutter

Interaction between vibration loading and material flaws, including sonic fatigue, fatigue-crack propagation, and residual static strength

Study of the practical effects of edge stiffeners, laminate residual stresses (due to thermal-expansion mismatch), and material damage on vibrational response

Increased attention to optimization for multiple criteria [163] and including material damping [91].

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four reviews each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the ***DIGEST*** reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

DAMPING IN STRUCTURAL JOINTS

C.F. Beards*

Abstract. Joint damping is the major source of inherent structural damping. Because of increasing demands for higher damping, joints must be carefully controlled to yield the maximum damping compatible with the duty of the structure. To this end, refined analyses of damping and force transfer mechanisms in joints are being developed, and the range of application of joint damping is being increased.

Most engineering structures require substantial damping if they are to operate with acceptable dynamic stress levels. Because the major source of inherent damping in fabricated structures arises in structural joints, damping in such joints has been a significant research topic for several years.

In a previous study of damping in structural joints [1], it was concluded that, because of the high energy sources now available and the low noise and vibration levels demanded, increased reliance on joint damping had become inevitable, as had the need to design more damping into structural joints. However, although the damaging effects of fretting corrosion can be controlled to some extent, and they may be preferable to the high vibration and stress levels that would otherwise exist in the structure, joint damping is rarely used efficiently because the small relative motions necessary between the joint interfaces can cause corrosion, loss of stiffness, and difficult design and analysis problems [2, 3].

JOINT ANALYSIS

The damping that occurs in a joint subjected to relative interfacial slip is due to a complex process of elastic and plastic deformation of contacting asperities, micro-slip and macro-slip [4, 5]. Analysis methods have often linearized the slip process; the results are of a qualitative nature but, nevertheless, have been useful for showing trends and optima and for modeling the macro-slip regime. Some simplification of the analysis has been thought desirable because multiple lock-ups per cycle have been found when two bodies with dry friction contact have been subjected to simple harmonic motion [6]; in addition, large fluctuations have occurred in the measured dynamic normal and friction contact forces during sliding [7]. Studies of friction slip [8], the dry friction damping mechanism [9, 10], and beams with friction damping at the end joints [11] have also provided information. A component mode analysis with nonlinear friction damper has been carried out [12].

The single point contact between joint interfaces that has been considered [13] is a more realistic model than simple linearization, however, and this approach could be extended to a finite element analysis. The approach is used to derive the equations of motion; the nonlinearities due to friction are represented by a pseudo-force vector. A theoretical joint model has been used to simulate the system [14]. An idealized contact of a number of spherical asperities of gaussian height distribution is made with flat surfaces. Each asperity contact is allowed either to deform elastically and plastically or to slide. Some of the experimental results show quantitative agreement, which is a considerable advantage of this method of analysis.

The characteristics of interface surfaces have been modeled [15]. A finite element model was derived and applied to a cantilever bolted to a rigid base to analyze the force distribution in a joint. A lumped parameter analysis method has also been proposed [16]. The forced response of a frictionally damped beam has also been

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calculated approximately using the finite element method [17].

Excitation has generally been considered to be harmonic. A stochastic analysis [18] and a seismic analysis [19] of a structure with friction joints have been published.

Fretting corrosion is an important consideration. Conditions that tend to accelerate fretting wear also tend to accelerate fretting fatigue failures [20]. No firm conclusions have been reached on the correlation of coating effectiveness in fretting wear and fretting fatigue although environmental effects have been studied [21]. Such effects may have important applications, particularly to outdoor structures.

Simple models of joints obtained from measured force transfer behavior have also been devised [22]. Formulation of the model coefficients with equivalent linearization maintained the nonlinear features with adequate accuracy and significantly reduced the difficulty of the analysis. However, the value of the analysis is reduced because measured joint data are used.

STRUCTURAL RESPONSE

A comprehensive theoretical and experimental assessment of the forced response of a cantilever beam with a dry friction damper attached resulted in some quantitative correlation; the agreement was mostly qualitative, however [23]. Study of the response of friction damped braced frames [24] led to a proposal that friction devices should be introduced in the bracing system of framed buildings to increase earthquake resistance. Further work on the control of frame vibration by increased friction damping in joints showed that a reduction in frame response of 21 dB could be obtained [25]. A linearized analysis provided useful but limited information. Friction damping has also been used to control the dynamic response of a flexible rotor [26]. Friction damping of flutter in gas turbine aerofoils, the forced response of bladed disc assemblies, and the response of turbine blades have been studied at some length [27-31].

The friction damping of laminated flat plates that are rivetted or bolted together has been studied [32]. The structural damping can be analyzed by a linear hysteretic model for circular plates. An interesting application of the friction damping of plate type structure has been in the control of noise emitted by a diesel engine oil sump [33].

CONCLUSIONS

It is becoming increasingly important to control the dynamic performance of a wide range of structures by optimizing the friction damping in joints. Joint damping has important application in the vibration of beams, cantilevers, braced frameworks, gas turbines, engine sumps, and other structures.

Linearized analyses, suitable for the macro-slip regime, are no longer sufficiently accurate for many joints. Clamping forces are such that current models of joint damping must include the random nature of asperity contact, elastic and plastic deformation of asperities, and both micro-slip and macro-slip.

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BOOK REVIEWS

UNDERWATER ACOUSTIC POSITIONING SYSTEMS

P.H. Milne
Gulf Publishing Co., Houston, TX
ISBNO-87201-012-0
1983, 284 pages, $49.95

This book is a sequel to Underwater Engineering Surveys, which dealt with various facets of underwater survey procedures necessary for offshore operators. Such operators are involved in activities ranging from the design and construction of coastal and offshore structures to their maintenance and periodic inspection. The first book dealt specifically with underwater surveying. The current text deals with underwater positioning systems.

The book contains ten chapters and three appendices. Chapter 1 introduces the reader to some background on the expansion of offshore exploration and developments that have led to the application of underwater acoustic systems. Chapter 2 discusses the main factors that influence the attenuation of sound and interference effects due to refraction and scattering. Ten methods for determining underwater position are discussed. Underwater positioning acoustic systems, called short baseline systems and consisting of hydrophones mounted in arrays measuring 5 to 20 meters, are characterized in Chapter 3. Chapter 4 describes supershort baseline acoustic systems that incorporate single transducers 230 mm in diameter. Long baseline acoustic methods of underwater positioning, consisting of arrays with baselines many meters long, are presented in Chapter 5. Various sonar systems have been developed for underwater navigation and obstacle avoidance, either as active or passive systems. Sonar selection is presented in Chapter 6. Maintaining ship position to the desired location -- that is, feedback control or dynamic positioning -- is presented in detail in Chapter 7. Some applications are given in Chapter 8. The six stages for dynamic positioning of surface vessels at offshore sites are defined in Chapter 9. The importance of underwater positioning of acoustic systems for inspection and maintenance purposes of offshore installations is dealt with in Chapter 10.

The three appendices are dedicated to the short, super-short, and long baseline systems described in Chapters 3, 4, and 5. Listings and printouts of the computer programs referred to in the text are given. The programs were developed for the Hewlett-Packard HP-85 and use BASIC. The software is compatible with the HP-83 and HP-87. A comprehensive list of pertinent and useful references follows the appendices.

This text does a commendable job of combining theory and practice in currently available hardware with such applications as surveying, off-shore structure positioning, and dynamic ship positioning. This book will be of interest to those engaged in this field and to those in the offshore oil industry who want a comprehensive synopsis of it.

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FUNDAMENTALS OF ACOUSTICS

L.E. Kinsler, A.R. Frey,
A.B. Coppens, and J.V. Sanders
John Wiley and Sons, New York, NY
1982, 480 pages, $37.95

Twenty years have passed since the second edition of this book was published, and the changes and additions made have improved this text. The addition of two authors to the Kinsler and Frey combination has added

important information that has brought the text up to date. This new material includes topics on normal mode propagation in water and environmental acoustics.

The first eight chapters deal with the fundamentals of sound and vibration, including the vibrations of a string, bar, membrane, and plate. Chapters 5 and 6 treat the wave equations and their transmission properties through fluids. The following two chapters cover the absorption, attenuation, radiation, and reception of waves.

The remaining chapters deal with a limited number of applications considered important by the authors; some have not been covered adequately or treated extensively in other texts. Chapters nine and ten deal with the behavior of acoustic waves when boundary geometry confines the wave to a limited space; situations include pipes and ducts. Hearing and speech are covered in Chapter 11; new material on environmental acoustics is discussed in Chapter 12. Topics in architectural acoustics are treated in Chapter 13. Chapter 14 is concerned with transduction and the application of theory to electroacoustic transducer design; e.g., microphones and loudspeakers. The use of sound waves in water to transfer information is covered in Chapter 15.

Many of the chapters are supplemented with material that reflects either advanced topics or recent concerns of the technical community. The complete appendix includes complex numbers, Bessel functions, directivity and impedance functions for a piston, vectors, and tables of physical properties of matter. Also included are an index and glossary of symbols.

The authors have done a good job of deriving the important equations from the laws of physics and of showing the logic involved. An extensive list of problems is placed at the end of each chapter; answers are given to the odd-numbered ones. The text will thus be useful for advanced undergraduate or graduate courses in acoustics. The working engineer will also find this book useful but may be disappointed at the lack of an extensive list of references. The book would be even better if it contained a complete bibliography.

This book will be useful to the working engineer or scientist and in college acoustic courses.

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DYNAMICS

S. Neil Rasband
John Wiley and Sons, New York, NY
1983, 272 pages

As stated by the author, "The subject of dynamics may be likened to a beautiful symphony with new depths of feeling and motion revealed at each additional hearing. —- The beauty of the symphony is intimately interwoven with the orchestration, so it is with mechanics. The language or garb in which the subject is presented can effect our personal attraction to the subject."

The book consists of ten chapters, a short section of references, and an index. Chapter 1 focuses on the physical concepts of mechanics in vector form. The standard (cylindrical, spherical) and moving coordinate systems are explained, as are displacement, velocity, and acceleration. Chapter 2 on Newtonian dynamics considers single and many point systems, phase curves, motion in one dimension, stability, and phase flow.

The next chapter introduces Lagrangian dynamics, including functional derivations and mapping of a Banach space. The Lagrangian equations are derived in generalized coordinates. Central force fields and Kepler's problem of the analysis of orbits in the Newtonian potential are described, as is the Lagrangian for particle motion in an electromagnetic field, the visualization of system motion with their resulting mapping, and the concept of Hamilton's principle of least action.

Chapter 4 is concerned with the dynamics of rigid bodies. Topics include general properties of the rigid body as a large collection of point particles, the moment of inertia, the inertia tensor, and Euler's equations of motion including torque.

Chapter 5 treats the dynamics of small oscillations. Euler-Lagrange equations are used in examples of coupled pendulums. The behavior of mechanical systems with changing parameters and parametric resonance are described in Lagrangian terms.

The next chapter deals with symmetries of mechanical systems, a partial solution of the equations of motion, invariants of motion, and tangent bundles. The derivative map, which can be defined as a derivative of manifolds and viewed as a linear part, is described, as is Noether's theorem -- the relationship of the symmetry of global properties of a physical system to the constant of motion.

Chapter 7 describes Hamiltonian dynamics. Included are the Lagrangian for a mechanical system, the Hamiltonian formulation, Hamilton's canonical equations and cotangent space, Poisson brackets, the Jacobian relation for Poisson brackets, and the Liouville theorem. An advantage of Hamiltonian dynamics is the concept that more general coordinates can be used than with the Lagrangian.

That motions of mechanical systems can be represented as trajectories in a cotangent bundle -- i.e., as curves in phase space --is the topic of Chapter 8. The chapter concludes with a discussion of the Hamilton-Jacobi equations that apply to the time evaluation of mechanical systems. From one complete integral of Hamilton's partial differential equation can be derived the solution of the integrals of Hamilton's equation of motion.

Chapter 9 on action-angle variables treats the variable for simple but typical systems. Consideration is given to invariant force, which includes the action momentum representation and also representation via Hamilton's equation. Stokes theorem is a generalization of the relationship between line and surface integrals. The concluding sections cover the Henon-Hiles system, which is another form of the Hamiltonian system and the KAM theorem. The latter infers that, for a small perturbation, a large number of invariant systems can be processed even though they may be significantly distorted.

The last chapter points to the algebraic aspects of motion. Algebraic properties of phase space vectors and functions are considered. LIE algebra is a vector space with a binary operation defined in the element of the vector space. The LIE derivative compares geometric objects along a flow.

This book is slanted toward the physics of quantum mechanics but contains basic dynamics that can be applied to engineering. The reviewer believes that a table of nomenclature and definitions would help the reader. An appendix describing vector methods would be an asset. Examples of gyroscopic stability and motion plus vibration of simple beams would make the book more appealing to engineering students. Another useful addition would be the Gibbs-Appell equations. The reviewer recommends this book to those interested in dynamics who have a good background in vectors and matrix theory.

H. Saunders
1 Arcadian Drive
Schenectady, NY 12302

HANDHELD CALCULATOR PROGRAMS FOR ROTATING EQUIPMENT DESIGN

L.E. Fielding
McGraw-Hill Book Co., New York, NY
1983, 447 pages, $39.95

The programs are designed for the handheld TI59 Texas Instrument calculator. The book contains three main parts: Vibration Analysis, Mechanical Design Analysis, and Fluid Dynamic Analysis. As stated by the author, "Each program has been written to be self-contained with a brief theory section. The theory section will permit the program user to ensure the applicability of a program to a particular problem without the need to refer to other sources. --- The book is intended to provide the design engineer with the capability of rapidly evaluating preliminary design -- and should be invaluable in the design of rotating equipment."

The 19 chapters contain derivations of the equations used in the programs. Chapter 1 of Part 1 introduces the reader to the lat-

eral critical speed program for a beam. The Myklestad-Prohl (MP) transfer matrix is used. The author derives the complete matrix including spring constraints; shear deformation should have been included. Chapter 2 discusses torsional critical speed of a beam using the Holzer method. Chapter 3 on rotor/bearing stability programs includes plain cylindrical, two-axial groove, three lobe, elliptical, offset cylindrical, and four tilting-pad bearings; stability margin and threshold programs are described.

Blade vibration in both lateral and torsional modes is the topic of the next chapter. The MP procedure is used for flexural vibration; the Holzer method is used for torsional vibration. Lateral and torsional properties of a section of an airfoil blade are described; shear deformation should have been included. Chapter 5 discusses programs for weight and inertia properties for arbitrary disks required in vibration analysis.

Chapter 6 begins Part II on mechanical design analysis. The programs are concerned with thermal disk stresses, inertia disk stress, and radial disk growth. Many have been used on large computers. More information on rim load design and associated programs would be a valuable addition. The next chapter focuses on simplification of blade stresses. The programs delete the effects of twisting and warping of complex shapes. Programs are described for centrifugal stress of blades, linear area taper blade including shroud, blade offset bending (axial and tangential), and blade gas bending. Chapter 8 addresses the shrink-fit of disks on rotors and tubes. Calculation of power transmitted by a shrink fit on a shaft with a uniform disk is the topic of Chapter 9. The next chapter considers bolt-torque tightening including a known preload. Maximum and minimum principle stresses are calculated from known torsional and tangential stresses in the bolt, the stresses are used in calculating the Von Mises stress. Programs for a multiple bolt arrangement subjected to thermal loading would have been useful.

Chapter 11 has to do with low cycle fatigue. Manson's uniform slope method in which the lower bound is obtained by the 10% rule is given. No mention is made of the Morrow-Lindgraf method for low cycle fatigue. Flat circular plates with central holes having simply supported and fixed ends are considered in Chapter 12; programs for uniform edge loading are given. The next chapter considers polynomial curve fit utilizing a Lagrange interpolating polynomial.

Chapter 14 begins Part III on fluid dynamic design. A description of compressible isotropic flow and derivation of the required formulas are included. The next chapter discusses flow through converging turbine blade channels; or irreversible adiabatic flow. The program utilizes typical equations governing one dimensional, adiabatic, irreversible flow. Chapter 16 contains derivations of the equations required to compress mixtures of water vapor and air needed in the design of air compression equipment.

The topic of Chapter 17 is the preliminary design of a turbine stage. A program for a mean line calculation of a turbine stage is given. The program uses specified input data to size the turbine, calculate velocity diagram data, and furnish an estimate of blading efficiency and a ratio of total to static efficiency. The next program provides radial variations by assuming free vortex design. The third program provides radial variations in the velocity diagram and flow parameters. It is assumed that the discharge angle of the nozzle is constant with radius. The concluding program solves, in closed form, equations defining efflux angle, which is a measure of the performance of a given blade row and is designated the direct approach. The indirect approach defines the blade geometry required for given thermodynamic calculations. The iteration method is employed to solve these equations.

Two programs in the next chapter are used for preliminary design of a compressor stage, including sizing the compressor and calculation of velocity diagram data. Due to storage limitations, assumptions are made as to rotor losses and solidity of stator and rotor.

The program in the concluding chapter uses specified data to calculate a one-dimensional centrifugal compressor stage and fur-

nishes the major dimensions of the impeller. Major parameters of specific speed, specific diameter, flow function, and head coefficient are computed. These parameters provide for assessing the feasibility of the assumed values for impeller and diffusor efficiencies.

Although slanted toward the TI59 handheld computer, the programs can be employed in large computers. All necessary formulas for preliminary design are furnished. The book would be better if equations were derived, then programs and examples were given. In addition, chapters on fracture mechanics and an introduction to finite elements should have been included.

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SHORT COURSES

DECEMBER

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: December 2-6, 1985
Place: Santa Barbara, California
Dates: February 3-7, 1986
Place: Santa Barbara, California
Dates: March 10-14, 1986
Place: Washington, DC
Dates: May 12-16, 1986
Place: Detroit, Michigan
Dates: June 2-6, 1986
Place: Santa Barbara, California
Dates: August 18-22, 1986
Place: Santa Barbara, California

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 -(805) 682-7171.

MACHINERY INSTRUMENTATION AND DIAGNOSTICS

Dates: December 3-6, 1985
Place: Houston, Texas

Objective: This course is designed for industry personnel who are involved in machinery analysis programs. Seminar topics include a review of transducers and monitoring systems, machinery malfunction diagnosis, data acquisition and reduction instruments, and the application of relative and seismic transducers to various types of rotating machinery.

Contact: Customer Information Center, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-3611, Ext. 9242.

FEBRUARY

MACHINERY VIBRATION ANALYSIS I

Dates: February 11-14, 1986
Place: Orlando, Florida
Dates: August 19-22, 1986
Place: New Orleans, Louisiana
Dates: November 11-14, 1986
Place: Chicago, Illinois

Objective: This course emphasizes the role of vibrations in mechanical equipment instrumentation for vibration measurement, techniques for vibration analysis and control, and vibration correction and criteria. Examples and case histories from actual vibration problems in the petroleum, process, chemical, power, paper, and pharmaceutical industries are used to illustrate techniques. Participants have the opportunity to become familiar with these techniques during the workshops. Lecture topics include: spectrum, time domain, modal, and orbital analysis; determination of natural frequency, resonance, and critical speed; vibration analysis of specific mechanical components, equipment, and equipment trains; identification of machine forces and frequencies; basic rotor dynamics including fluid-film bearing characteristics, instabilities, and response to mass unbalance; vibration correction including balancing; vibration control including isolation and damping of installed equipment; selection and use of instrumentation; equipment evaluation techniques; shop testing; and plant predictive and preventive maintenance. This course will be of interest to plant engineers and technicians who must identify and correct faults in machinery.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MARCH

MEASUREMENT SYSTEMS ENGINEERING
Dates: March 10-14, 1986
Place: Phoenix, Arizona
MEASUREMENT SYSTEMS DYNAMICS
Dates: March 17-21, 1986
Place: Phoenix, Arizona
Objective: Electrical measurements of mechanical and thermal quantities are presented through the new and unique "Unified Approach to the Engineering of Measurement Systems." Test requestors, designers, theoretical analysts, managers and experimental groups are the audience for which these programs have been designed. Cost-effective, valid data in the field and in the laboratory, are emphasized. Not only how to do that job, but how to tell when it's been done right.

Contact: Peter K. Stein, Director, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603; (602) 947-6333.

APRIL

MACHINERY VIBRATION ANALYSIS II
Dates: April 28 - May 2, 1986
Place: Syria, Virginia
Objective: The objective of this course is to expose participants to advanced techniques of vibration analysis using single- and dual-channel FFT analyzers. These techniques include analysis of spectrum, time, frequency, and orbital domain; modal analysis; coherence, frequency response functions, and synchronous time averaging; and amplitude, phase, and frequency modulation. Data processing procedures are reviewed. All techniques are illustrated with examples and case histories of industrial machinery. Instrumentation necessary to implement the techniques is available for use by participants during informal workshops; taped data from actual industrial machinery are used during these workshops.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

JULY

ROTOR DYNAMICS
Dates: July 14-18, 1986
Place: Rindge, New Hampshire
Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and nonlinear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation, and case histories involving the power and petrochemical industries.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

AUGUST

VIBRATIONS OF RECIPROCATING MACHINERY
Dates: August 19-22, 1986
Place: New Orleans, Louisiana
Objective: This course on vibrations of reciprocating machinery includes piping and foundations. Equipment that will be addressed includes reciprocating compressors and pumps as well as engines of all types. Engineering problems will be discussed from the point of view of computation and measurement. Basic pulsation theory --including pulsations in reciprocating compressors and piping systems -- will be described. Acoustic resonance phenomena and digital acous-

tic simulation in piping will be reviewed. Calculations of piping vibration and stress will be illustrated with examples and case histories. Torsional vibrations of systems containing engines and pumps, compressors, and generators, including gearboxes and fluid drives, will be covered. Factors that should be considered during the design and analysis of foundations for engines and compressors will be discussed. Practical aspects of the vibrations of reciprocating machinery will be emphasized. Case histories and examples will be presented to illustrate techniques.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

SEPTEMBER

MODAL TESTING OF MACHINES AND STRUCTURES

Dates: September 8-11, 1986
Place: Chicago, Illinois
Objective: Vibration testing and analysis associated with machines and structures will be discussed in detail. Practical examples will be given to illustrate important concepts. Theory and test philosophy of modal techniques, methods for mobility measurements, methods for analyzing mobility data, mathematical modeling from mobility data, and applications of modal test resulks will be presented.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

WORKSHOP ON DYNAMICS AND AEROELASTIC STABILITY MODELING OF ROTOR SYSTEMS December 4-5, 1985

A workshop on "Dynamics and Aeroelastic Stability Modeling of Rotor Systems" is scheduled for December 4-5, 1985. This workshop is being jointly organized by the Army Research Office and the Georgia Institute of Technology. Local arrangements are being made by Prof. Daniel Schrage and Mr. Steven Meyer. Planned activity at the Workshop consists of invited lectures and contributed papers.

The objective of this workshop is to assess the state of the art in the mathematical modeling of and development of solution techniques for the differential equations of motion of rotors in helicopter and tilt rotor aircraft. The following topics will be covered in the workshop:

Formulation of Rotor Blade Equations of Motion
Structural Modeling of Composite Rotor Blades
Rotor Modeling Impact on Solution Techniques

For further information contact: Dr. Gary L. Anderson, US Army Research Office, P.O. Box 12211, Research Triangle Park, NC 27709-2211 - (919) 549-0641, Ext. 317.

ABSTRACTS FROM THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

None of the publications are available at SVIC or at the Vibration Institute, except those generated by either organization.

Periodical articles, society papers, and papers presented at conferences may be obtained at the Engineering Societies Library, 345 East 47th Street, New York, NY 10017; or Library of Congress, Washington, D.C., when not available in local or company libraries.

Government reports may be purchased from National Technical Information Service, Springfield, VA 22161. They are identified at the end of bibliographic citation by an NTIS order number with prefixes such as AD, N, NTIS, PB, DE, NUREG, DOE, and ERATL.

Ph.D. dissertations are identified by a DA order number and are available from University Microfilms International, Dissertation Copies, P.O. Box 1764, Ann Arbor, MI 48108.

U.S. patents and patent applications may be ordered by patent or patent application number from Commissioner of Patents, Washington, D.C. 20231.

Chinese publications, identified by a CSTA order number, are available in Chinese or English translation from International Information Service, Ltd., P.O. Box 24683, ABD Post Office, Hong Kong.

Institution of Mechanical Engineers publications are available in U.S.: SAE Customer Service, Dept. 676, 400 Commonwealth Drive, Warrendale, PA 15096, by quoting the SAE-MEP number.

When ordering, the pertinent order number should always be included, not the **DIGEST** abstract number.

A List of Periodicals Scanned is published in issues, 1, 6, and 12.

MECHANICAL SYSTEMS

ROTATING MACHINES

85-2200
Seismic Analysis of Rotating Mechanical Systems
A.H. Soni, V. Srinivasan
Oklahoma State Univ., Stillwater, OK
Rept. No. NSF/CEE-84042, 252 pp (June 1984), PB85-149599/GAR

KEY WORDS: Rotating structures, Seismic analysis, Computer programs

Three mathematical models are developed to model a rotating mechanical system in the time domain; earthquake excitation is assumed to be a deterministic function of time. The rigid body model models the rotating system as a rigid body spinning in space, and includes factors such as gyroscopic effects, rotor bearing interaction effects, base rotation (including Coriolus effects), and base translation. The three-dimensional elasticity model incorporates the flexibility of the system using the three-dimensional theory of elasticity. Numerical examples are presented for each of the models, and results of the examples are presented in graphic form.

85-2201
Dynamical Behavior of Disklike Rotating Tools
H.K. Tonshoff, J. Jendryschik
Univ. of Hannover, Fed. Rep. Germany
Computers Struc., 21 (1/2), pp 203-211 (1985), 14 figs, 1 table, 17 refs

KEY WORDS: Rotating machinery, Tools, Flexural vibration, Saws

Metals, plastics, ceramics, wood, concrete, and products such as silicon wafers are cut with disklike rotating tools, but problems in application exist because of the low flexural tool stiffness. A little perturbation can cause flexural vibrations which lead to dimensional errors and rough surfaces of the workpiece. At the tools' critical rotating speed run-out effects occur, i.e., deviation from the required cutting line. Objectives of the analysis are process simulation and investigations of the interference between run-out and disk damping with the help of the finite element program ADINA.

85-2202
On the Excitations due to the Periodic Structure of Turbomachines (Uber die Erregung infolge der Periodizitat von Turbomaschinen)
M. Dubas
Entwicklung Hydraulik, Sulzer-Escher Wyss AG Postfach, CH-8023, Zurich, Switzerland
Ing. Arch., 54 (6), pp 413-426 (1984), 6 figs, 2 tables, 13 refs (In German)

KEY WORDS: Turbomachinery, Blades, Shafts, Disks

Excitation caused by the periodical character of the rotor and the stator of turbomachines of any kind is investigated. The basic assumption is that each time a runner blade passes a guide vane, a radial, tangential, and axial load are produced. With the help of three simple mathematical models the forces and moments, especially their frequencies resulting from all these loads, are determined.

85-2203
Current Research on Circular Saw and Band Saw Vibration and Stability
C. D'Angelo, III, N.T. Alvarado, K.W. Wang, C.D. Mote, Jr.
Univ. of California, Berkeley, CA
Shock Vib. Dig., 17 (5), pp 11-23 (May 1985), 5 figs, 4 tables, 79 refs

KEY WORDS: Circular saws, Reviews

The topics covered in this review are circular saw and band saw vibration; saw guides, which are fluid-film bearings used to control saw position and vibration; guided saw vibration; and generation of noise by

vibration and aerodynamic sources in high-speed sawing.

METAL WORKING AND FORMING

85-2204
Diagnosing the Chatter as Mode Coupling by Measuring Phase
Yu Junyi, Zheng Detao
Chinese J. Mech. Engrg., 20 (3), pp 61-72 (1984), CSTA No. 621.8-84.28

KEY WORDS: Cutting, Chatter

Diagnostic principles and methods in chatter mode coupling are discussed.

STRUCTURAL SYSTEMS

BRIDGES

85-2205
Finite Element, Modal Coordinate Analysis of Structures Subjected to Moving Loads
M. Olsson
Lund Univ., Lund, Sweden
J. Sound Vib., 99 (1), pp 1-12 (Mar 8, 1985), 7 figs, 1 table, 10 refs

KEY WORDS: Railroad bridges, Moving loads, Railroad trains, Finite element technique, Bridge-vehicle interaction

Some of the possibilities of the finite element method in the moving load problem are demonstrated. The bridge-vehicle interaction phenomenon is considered by deriving a general bridge-vehicle element. This element may be regarded as a finite element with time-dependent and unsymmetric element matrices. The bridge response is formulated in modal coordinates thereby reducing the number of equations to be solved within each time step. Illustrative examples are shown for the special case of a beam bridge model and a one-axle vehicle model.

85-2206
Seismic Research for Highway Bridges (U.S.-Japan Program)
J.F. Fleming
Univ. of Pittsburgh, Pittsburgh, PA
Rept. No. NSF/CEE-84034, 685 pp (June 1984), PB85-152148/GAR

KEY WORDS: Bridges, Seismic analysis, Seismic design

Papers address either the seismic design or evaluation of bridges. The papers focus on such topics as seismic resistant bridge design in California, specifications for the earthquake resistant design of Japanese high bridges, response of cable stayed bridges to static and dynamic loads, seismic vulnerability of prestressed concrete segmental bridges, behavior of concrete-filled steel tubes, repair and retrofit work on road bridge substructures, rehabilitation of road transportation networks damaged by earthquakes, and retrofitting bridges to increase their seismic resistance.

BUILDINGS

85-2207
Dynamic Response of Discretely Damped Structures under Harmonic and Random Excitation
W.K. Wheeler, G.J. Hancock
Sydney Univ., Sydney, Australia
Rept. No. R-475, 35 pp (July 1984), PB85-135663/GAR

KEY WORDS: Multistory buildings, Bridges, Cable stayed structures, Harmonic excitation, Random excitation

This paper describes an analysis based on the frequency response method for studying the dynamic response of framed structures under both harmonic and random excitation.

Studies of a multi-story frame structure and a cable stayed pedestrian footbridge are described. These studies include investigations of the location and magnitude of the dampers.

85-2208
Nonlinear Analysis of Reinforced Concrete Frame-Shearwall Structures Subjected to Earthquake Motion (User's Guide to DRAIN-2D: EL7 for RC Shearwalls)
A. Kumar, J.K. Wight
Univ. of Michigan, Ann Arbor, MI
Rept. No. UMEE-83R4, NSF/CEE-83043, 65 pp (Oct 1983), PB85-150241/GAR

KEY WORDS: Multistory buildings, Seismic response, Cyclic loading, Reinforced concrete, Computer programs

This report characterizes Element EL17, a general purpose element for reinforced concrete shearwalls under cyclic loading. The development of the element for use in the DRAIN-2D computer program for calculating the nonlinear response of multistory structures subject to earthquake motion is described, and the FORTRAN listing of the subroutines is included. Input data and sample computer output for a seven-story reinforced concrete frame-wall structure are presented to illustrate the data preparation procedure and output format for the shearwall element. The tangent stiffness matrix of the shearwall element is provided.

85-2209
Control Systems on Earthquake Resistance of Steel Structures - H-shaped Steel Damper and Earthquake Resisting Panel
T. Yamada, O. Kojima, A. Ninomiya
Nippon Kokan K.K., Tokyo, Japan
12 pp (1984), PB85-134211/GAR (In Japanese)

KEY WORDS: Buildings, Seismic design, Steel

Two aseismic elements were developed mainly for steel structures. These are capable of restricting the elastic deformation of the structure during the moderate earthquakes and of increasing the energy absorbing capacity during the strong earthquakes. One is the H-shaped steel damper, which is an H-shaped steel of specified length installed between the beam of the existing structure and the added reinforcing frame. The other is the earthquake resisting panel, which is composed of the horizontal and vertical members of a light steel and their joints are rigidly connected by the rib or gusset plate. The results of static and dynamic loading tests and the theoretical analysis are shown.

TOWERS

85-2210
Wind Effects on High Cooling Towers
J.F. Sageau, M. Robert
Electricite de France, Chatou, France
Flow Induced Vibrations Symposium, Vol. I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec. 9-14, 1984, pp 129-143, 11 figs, 5 tables, 7 refs

KEY WORDS: Cooling towers, Wind-induced excitation

A program to provide design criteria adapted to the new generation of cooling towers was initiated. This program included three components: the determination of loadings, the static response of the tower, and the dynamic response of the tower.

85-2211
Inelastic Seismic Response of Braced Towers Supporting Tanks
M.A. Haroun, N.M. Haroun, H.M. Ellaithy
Univ. of California, Irvine, CA 92717
Computers Struc., 20 (1-3), pp 605-613 (1985), 8 figs, 3 tables, 12 refs

KEY WORDS: Water towers, Seismic response

This paper deals with the second phase of a research project to analyze the earthquake response of elevated tanks. Emphasis is placed on the inelastic behavior of a typical cross-braced tower. A simplified model consisting of a simple multilinear force-displacement function is used.

85-2212
Free and Random Vibrations of Column-Supported Cooling Towers
Y. Yong, Y.K. Lin
Univ. of Illinois, Urbana-Champaign, IL 61801
J. Sound Vib., 98 (4), pp 539-563 (Feb 22, 1985), 12 figs, 21 refs

KEY WORDS: Cooling towers, Shells, Columns, Seismic excitation, Wind-induced excitation

A transfer matrix formulation is used to develop an efficient algorithm to analyze the dynamic behavior of a cooling-tower structure, which consists of a thin hyperbolic shell of revolution supported at the base by flexible columns. The paper is divided into three parts: free vibration, seismic excitation, and wind excitation.

FOUNDATIONS

85-2213
On the Formal Development of Elastic Foundation Models
A.D. Kerr
Univ. of Delaware, Newark, DE 19716
Ing. Arch., 54 (6), pp 455-464 (1984), 6 figs, 19 refs

KEY WORDS: Elastic foundations, Power series method, Mathematical models

A procedure which makes use of formal power series expansions is used in developing foundation models. It is shown that the a priori assumption that the contact pressure is related to the surface deflections and its derivatives is too restrictive. A comparison of the obtained models and a discussion of the sequencing of foundation models of higher order beyond the Winkler foundation are presented.

85-2214
Structure-Foundation Interactions Under Dynamic Loads
Wen David Liu
Ph.D. Thesis, Univ. of California, 222 pp (1984), DA8427032

KEY WORDS: Structure-foundation interaction, Pile foundations, Bridges, Time domain methods, Computer programs

Structure-foundation interactions as characterized by the dynamic foundation stiffnesses are studied for embedded foundations and single piles under the framework of the general substructure method. A pilot case study has been conducted for a six-span segment of a typical highway bridge structure to illustrate the foundation effects.

85-2215
Seismic Analysis of Three-Dimensional Soil-Structure Interaction System on a Rectangular Base
S. Saylan, T.G. Toridis, K. Khozeimeh
George Washington Univ., Washington, DC 20052
Computers Struc., 20 (1-3), pp 355-363 (1985), 9 figs, 34 refs

KEY WORDS: Soil-structure interaction, Seismic analysis, Finite element technique

An analytical procedure is presented for determining the three-dimensional interaction effects of a soil-structure system under seismic excitation. The structure is modeled as an assembly of finite elements representing the three-dimensional superstructure that is attached to a rectangular base on a half-space. Using triple Fourier transform techniques, dynamic displacement equations of the three-dimensional elastic half-space are solved. Solutions are presented in closed form. Based on specific values of some of the basic parameters of

the problem, numerical results are obtained and presented in the form of a series of curves associated with the dynamic response of a rectangular base.

85-2216
Interaction of Nonlinear Interiors with Linear Infinite Exteriors
Lee-Jen Lee, G. Dasgupta
Columbia Univ., New York, NY
Computers Struc., 20 (1-3), pp 339-353 (1985), 16 figs, 18 refs

KEY WORDS: Soil-structure interaction, Finite element technique

The dynamic response of a nonlinear structure-soil system supported by homogeneous linear soil is formulated. The near field is modeled by finite elements, and its motion is represented by a differential equation in the time domain. The boundary conditions are furnished by the force-displacement relationship of the exterior. The effects of the outgoing waves are captured by the frequency-dependent boundary stiffness matrices. The numerical technique developed herein furnishes a computer scheme to carry out design and analysis of structures under arbitrary dynamic excitations, including the local nonlinear effects of the supporting soil.

85-2217
Spring Stiffnesses for Beam-Column Analysis of Soil-Structure Interaction Problems
R.L. Hall
Ph.D. Thesis, Oklahoma State Univ., 133 pp (1984), DA8427669

KEY WORDS: Soil-structure interaction, Beam-columns, Foundations, Finite element technique

Soil pressures acting on slabs on grade and U-frame structures control their design. These structures must be designed to account for the interaction between the soil and structures. Two procedures which can be used for preliminary design of these structures accounting for the interaction between the structure and the soil foundation are described.

85-2218
Radial Vibrations in Cylindrical Soil Massive in Plastic Yield State
T. Raghavan, V.P. Muthuswamy
Sacred Heart College, TIRUPATTUR NA, 635 601, India
Rev. Roumaine Sci. Tech., Mecanique Appl., 30 (1), pp 31-36 (Jan/Feb 1985), 3 refs

KEY WORDS: Soils, Cylinders, Concentric structures, Radial vibrations

Radial vibrations of soil massive in the form of a cylinder are studied. The cylinder is supposed to have a rigid coaxial cylindrical inclusion. The soil massive, excepting the rigid inclusion, is supposed to be in the plastic yield state. Solutions are obtained for two types of soils, using the Laplace transform and the complex inversion functions.

85-2219
Response of Saturated Porous Nonlinear Materials to Dynamic Loadings
K.J. Kim, S.E. Blouin
Applied Res. Associates, South Royalton, VT
Rept. No. AFOSR-TR-84-1102, 103 pp (May 31, 1984), AD-A148 528/3/GAR

KEY WORDS: Computer programs, Finite element technique, Soils, Fluid-filled media

Past theoretical treatments of two phase media are reviewed and incorporated into the two phase dynamic finite element code TPDAP. A study of the response of two phase porous elastic media to dynamic uniaxial loadings is conducted and the influence of loading shape, material properties, and numerical techniques and parameters are evaluated. A series of calculations simulating uniaxial loadings of saturated soils having hysteretic skeletons is conducted.

HARBORS AND DAMS

85-2220
A Semi-Analytical Method for Seismic Analysis of Arch Dam
Cao Zhiyuan, Zhang Yaoqin
J. Hydraulic Engrg., (8), pp 26-36 (1984), CSTA No. 627-84.69

KEY WORDS: Dams, Seismic analysis

A change of the cross-section finite thick shell strip method is applied for seismic analysis of an arched dam. This method makes use of simple polynomials in transverse river direction, and analytical functions in height direction of the dam and the river. The three dimension problem was changed into a one dimension problem to have its values solved. As it saves much storage space and computer time, this method is preferred over the finite element method.

85-2221
Earthquake Response of Concrete Gravity Dams
G.L. Fenves
Ph.D. Thesis, Univ. of California, Berkeley, 237 pp (1984), DA8426959

KEY WORDS: Dams, Seismic response

The objectives of this work are to develop efficient techniques for analyzing the earthquake response of concrete gravity dams, and to investigate how dam-water-foundation rock interaction and sediments at the bottom of reservoirs affect the dam response.

POWER PLANTS

85-2222
Sensitivity of Peak Dynamic Responses to Input Factors
W.J. O'Connell
Lawrence Livermore National Lab., CA
Rept. No. UCRL-86250, CONF-840913-6, 19 pp (June 1984), DE 85000756/GAR

KEY WORDS: Nuclear power plants, Seismic analysis, Nuclear reactor components, Computer programs, Pipelines

The sensitivity of calculated peak dynamic responses, such as acceleration and moment are examined to input parameters such as frequency and damping. These responses have been calculated for the Zion Unit 1 plant using the computer code SMACS as part of the seismic probabilistic risk assessment.

85-2223
Dynamic Response of an LMFBR Deck Structure Under Slug Impact
G. Saurer, R. Wanner, H. Palsson, C. Inversini
Swiss Federal Inst. for Reactor Res., Switzerland
Computers Struc., 21 (1/2), pp 159-164 (1985), 6 figs, 2 tables, 10 refs

KEY WORDS: Nuclear reactor containment, Concrete, Impact response

An important concern in the safety analysis of liquid-metal fast breeder reactors (LMFBR) is the dynamic response of the primary containment to the impact of the fluid occurring during a hypothetical core disruptive accident. It is possible that a substantial part of the kinetic energy gained by the coolant from the energy released by the core is transferred to the deck structure which, however, should retain its integrity in order to prevent leakage of radioactive material to the environment. The dynamic response of the deck structure of a pool-type plant of commercial size is analyzed in a generic study using the program ADINA.

85-2224
Reduction of Vibration Caused by Flow in an Annular Diffuser
M.W. Parkin, P.C. Watson
Windscale Nuclear Power Dev. Labs.

UKAEA, Seascale, Cumbria, UK
Flow-Induced Vibrations Symp., Vol. 4, Vibration Induced by Axial and Annular Flows, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 1-14, 20 figs, 9 refs

KEY WORDS: Vibration reduction, Fluid-induced excitation, Nuclear fuel elements

A physical model explaining flow induced vibration observed in 6° and 30° annular diffusers where the center body forming the diffuser has freedom to move radially is described. The model is based on experimental evidence, and accounts for both fluid behavior and structural response. Two vibration suppression devices, both of which have performed successfully in realistic demonstration tests, are also described.

85-2225
Instabilities of the AGR Fuel Assembly During On-Load Refuelling
D.E. Hobson
CEGB Marchwood Engrg. Labs., Marchwood, Southampton, UK
Flow Induced Vibrations Symp., Vol. 4, Vibration Induced by Axial and Annular Flows, ASME Winter annual mtg., New Orleans, LA, Dec 9-14, 1984, pp 25-39, 8 figs, 11 refs

KEY WORDS: Nuclear fuel elements, Fluid-induced excitation

During on-load refueling of the Advanced Gas Cooled Reactor (AGR), gas flows at high velocity in the annular passage between the cylindrical fuel assembly and the channel in the reactor core, causing the assembly to vibrate. The characteristics of the vibration are governed partly by the structural dynamics of the assembly. Because of narrowness, the coupling between the fluid and the structure is enhanced and this can lead to large transverse fluid forces when the assembly moves from its mean concentric position. The ways in which these forces can cause self-excited vibration of various structures, including one, two or more degrees of freedom systems, or a semi-infinite beam representing a fuel assembly, are discussed in an attempt to explain the observed behavior of the actual assembly during on-load refueling, and in particular why stability is governed by the detailed aerodynamic behavior of part of the annulus just above the reactor core.

85-2226
Flow-Induced Vibration: Guidelines for Design, Diagnosis, and Troubleshooting of Common Power Plant Components
M.K. Au-Yang
Babcock and Wilcox, Lynchburg, VA
Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME winter annual mtg., New Orleans, LA, Dec 9-14, 1984, pp 119-137, 3 figs, 41 refs

KEY WORDS: Nuclear power plants, Structural members, Fluid-induced excitation, Plates, Cylindrical shells

The different techniques of accessing the flow-induced vibration problems of common power plant components are reviewed. The components are divided into categories of single cylinders, flat plates, pipes containing flowing fluid, cylindrical shells and tube banks. The mechanisms considered include turbulent buffeting, instability, vortex shedding, acoustics and leakage flow-induced vibration. Emphasis is placed on applications to industrial problems.

OFF-SHORE STRUCTURES

85-2227
Transient Loading of Pile-Shell-Type Supported Offshore Structures
V.A. Dzhupanov, D.D. Karagozova, V.M. Vassilev
Bulgaria Academy of Sciences, Inst. of Mechanics and Biomechanics, Sofia, Bulgaria
Flow Induced Vibrations Symp., Vol. I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec. 9-14, 1984, pp 189-201, 7 figs, 1 table, 26 refs

KEY WORDS: Offshore structures, Fluid-structure interaction, Transient excitation, Successive approximation method

The description of an offshore scaffold bridge consisting of bridge deck supported by a row of pile-shells is given. The transient loadings are discussed. The problem of the dynamical structure-liquid interaction is solved by a method of successive approximations. Engineering estimations are presented.

85-2228
Wave Effects on Large Offshore Structures of Arbitrary Shape
Wu Zongren, M.Q. Isaacson
China Civ. Engrg. J., 17 (3), pp 11-22 (1984), CSTA No. 624-84.64

KEY WORDS: Offshore structures, Wave forces, Computer programs

A method is introduced for the numerical solution of wave effects on large offshore structures of arbitrary shape. It is based on a wave source distribution utilizing the Green's function. A corresponding computer program has been developed, which may be used to obtain wave forces and moments, wave pressure distribution and runup on fixed bodies, and also wave exciting forces and moments, added-mass and damping coefficients and responses for floating bodies.

VEHICLE SYSTEMS

GROUND VEHICLES

85-2229
Application of Hammering Method on Research on Dynamic Characteristic of Walking Tractor
Su Qingzu
Trans. Chinese Soc. of Agri. Mach., 15 (3), pp 21-29 (1984), CSTA No. 631.3-84.20

KEY WORDS: Tractors, Modal analysis, Impact hammer tests

This paper describes briefly the basic theory of modal analysis with the hammering method and a testing technique for measuring transfer functions between type and handle of a walking tractor. Some modal parameters were directly identified from the measured data of these transfer functions. The results show that the hammering method is an easy and feasible approach for measuring dynamic characteristics of some parts of a tractor.

SHIPS

85-2230
On Analysis of Structural Response of Ship Panels Subjected to Air Blast Loading
R. Houlston, J.E. Slater, N. Pegg, C.G. DesRochers
Defence Res. Establishment Suffield, Ralston, Alberta, Canada
Computers Struc., 21 (1/2), pp 273-289 (1985), 21 figs, 1 table, 10 refs

KEY WORDS: Ships, Air blast, Damage prediction, Finite element technique

In combat operations, warships could be subjected to air blast and underwater shock loads capable of causing considerable structural damage. This paper concentrates on the prediction and measurement of the structural response of ship panels to free field air-blast explosions. Experiments with steel plates and full scale stiffened panels are described. Finite element modeling and analysis are presented and compared with experimental results.

AIRCRAFT

85-2231
Modelling for Fatigue Crack Growth Prediction in Mirage IIIO Frame 26

J.M. Finney, F.G. Harris, R.A. Pell, C.S. Dentry
Aeronautical Res. Labs., Melbourne, Australia
Rept. No. ARL-STRUC-401, 78 pp (Apr 1984), AD-A149 237/0/GAR

KEY WORDS: Aircraft, Fatigue life, Crack propagation

Constant- and variable-amplitude fatigue crack growth data have been obtained for A7-U4SG-T651 (2214) aluminum alloy applicable to frame 26 of Mirage IIIO aircraft, enabling calibration of computer models of crack growth.

85-2232
Use of Adhesive-Bonded Rivets to Lessen the Reductions in Fatigue Life Caused by Rivet Holes
J.Y. Mann, R.A. Pell, R. Jones, M. Heller
Aeronautical Res. Labs., Melbourne, Australia
Rept. No. ARL-STRUC-399, 48 pp (Mar 1984), AD-A149 236/2/GAR

KEY WORDS: Aircraft, Fatigue life, Riveted joints

Rivet holes are potential sites for fatigue crack initiation in aircraft structures. Several methods for improving the life of such details were investigated including coating the surface of the hole with adhesive, cold-expansion of the holes, the insertion of close-fit rivets and the use of adhesively-bonded rivets.

85-2233
Unsteady Stall Penetration of an Oscillating Swept Wing
F.O. Carta
United Technologies Res. Ctr., East Hartford, CT
10 pp (1984), Proc. of Workshop on Unsteady Separated Flow, at U.S. Air Force Academy, Aug 10-11, 1983, pp 28-37, AD-P004 156/6/GAR

KEY WORDS: Aircraft wings, Stalling

Results include: mean angle of attack, motion amplitude, and Mach number effects on wave speed.

85-2234
Visual Study of a Delta Wing in Steady and Unsteady Motion
M. Gad-el-Hak, C.M. Ho, R.F. Blackwelder
Flow Research Co., Kent, WA
7 pp (1984), Proc. Workshop on Unsteady Separated Flow Held at the U.S. Air Force Academy on Aug 10-11, 1983, pp 45-51, AD-P004 158/2/GAR

KEY WORDS: Aircraft wings, Vortex shedding

Two delta wings with a leading edge sweep of 45 deg and 60 deg were studied in a towing tank at chord Reynolds number up to 350,000.

MISSILES AND SPACECRAFT

85-2235
Missile Launcher Integral Shock Isolation and Running Gear System
C. Brumen
Dept. of Air Force, Washington, DC
U.S. Patent Appl. No. 6-671 391/GAR

KEY WORDS: Missile launchers, Shock isolation, Gears

An integral, shock-isolated running gear unit for incorporation into a missile launcher was studied. These integral units compromise a combination of actuators and rolling devices which are cooperable with tracks defined in opposite walls of a shelter for controlling the displacement of the launcher within the shelter.

85-2236
The Asymptotic Property of the Flying Attitude of the Slender Vehicle
Yu Jingyuan, Zhu Guangtian

SSA, 27 (9), pp 990-1002 (1984), CSTA No. 629.1-84.30

KEY WORDS: Structural damping

The elastic vibration analysis of a slender space vehicle with structural damping has been studied. Applying the perturbation theory for linear operators, the perturbation features of the spectrum of the principal operator and the asymptotic property of its semi-group are given.

85-2237
Damping Synthesis and Damped Design for Flexible Spacecraft Structures
M.L. Soni, M.F. Kluesener, M.L. Drake
Univ. of Dayton Res. Inst., Dayton, OH 45469
Computers Struc., 20 (1-3), pp 563-574 (1985), 7 figs, 6 tables, 17 refs

KEY WORDS: Spacecraft, Damping synthesis

The prediction and enhancement of damping of flexible spacecraft structures is studied. Methods of damping synthesis are briefly reviewed and an improved synthesis method is developed. Two example problems are given illustrating the validity of the damping synthesis. The results of several passive designs developed and evaluated on a representative flexible appendage are discussed.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

85-2238
Effect of Sealants of the Sound Absorption Coefficients of Acoustical Friable Insulating Materials
J.L. Wayman, M.K. Lory
Naval Postgraduate School, Monterey, CA
Rept. No. NPS-53-85-4, 15 pp (Oct 1984), AD-A148 541/6/GAR

KEY WORDS: Acoustic absorption, Seals

Because of their widespread use and the ease of fiber dissemination, friable asbestos materials are considered to be the major source of asbestos fiber contamination in the indoor environment. Encapsulation of asbestos materials with a commercial sealant product is one of several methods used to control potential asbestos exposure in rooms. A sealant product that preserves most of the acoustical properties of the material is preferred in this usage.

85-2239
Experimental Study of Active Vibration Control
W.L. Hallauer
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA
Rept. No. AFOSR-TR-84-955, 25 pp (Oct 1983), AD-A148 333/8/GAR

KEY WORDS: Active vibration control, Beams, Cables, Grids, Spacecraft

Active vibration control was implemented on two laboratory structures having some important dynamic characteristics of large space structures: a dynamically uncomplicated beam-cable structure and a dynamically complicated plane grid structure. The control techniques used are direct-velocity-feedback control, with a single colocated sensor-actuator pair, and modal-space control, with a single sensor and several actuators. The most challenging control task attempted was modal-space control of five low frequency modes of the plane grid structure, including a closely spaced pair.

85-2240
Motor Vehicle Suspension Systems: Vibrational Effects and Stability. 1973-January 1985 (Citations from Information Services in Mechanical Engineering Data Base)
NTIS, Springfield, VA
134 pp (Jan 1985), PB85-853810/GAR

KEY WORDS: Suspension systems (vehicles), Bibliographies

This bibliography contains 257 citations concerning the effects of vibration and ride stability, uneven tire wear, and resulting steering difficulties associated with motor vehicle suspension systems.. Hydropneumatic leveling, independent suspension, and active suspension systems are discussed.. The use of composite materials, such as fiberglass in suspension springs is also presented.

85-2241

A Mixture Theory for Wave Propagation in Angle-Ply Laminates. Part 1: Theory

H. Murakami
Univ. of California, San Diego, CA 92093

J. Appl. Mech., Trans. ASME, 52 (2), pp 331-337 (June 1985) 3 figs, 19 refs

KEY WORDS: Layered materials, Wave propagation, Shock absorbers

In an effort to construct a continuum model with microstructure for elastic angle-ply laminates, an asymptotic mixture theory with multiple scales is presented. The theory, which is in the form of a binary mixture, can simulate wave propagation in linearly elastic laminated composites with orthotropic lamina. Reissner's new variational principle has been adopted to avoid the numerous solution procedures of microstructure boundary value problems, which are required to find mixture properties in terms of the geometrical and material properties of the two constituents of the composite.

85-2242

A Mixture Theory for Wave Propagation in Angle-Ply Laminates. Part 2: Application

H. Murakami, A. Akiyama
Univ. of California, San Diego, CA 92093

J. Appl. Mech., Trans. ASME, 52 (2), pp 338-344 (June 1985), 7 figs, 9 refs

KEY WORDS: Layered materials, Wave propagation, Shock absorbers

A binary mixture theory with microstructure is constructed for symmetric angle-ply laminates with orthotropic laminas for wave motion in arbitrary directions. A numerical study of phase-velocity spectra associated with the resulting theory reveals that dispersion is most prominent in waveguide propagation. Further, it is directionally dependent and may be strong depending on the propagation direction and lay-up angle. Typical results are presented for a graphite/epoxy composite To assess the accuracy of the mixture model, a finite element eigenvalue analysis has been carried out.

85-2243

Implementation of Base Isolation for the Foothill Communities Law and Justice Center

A.G. Tarics, D. Way, J.M. Kelly
Reid and Tarics Associates, San Francisco, CA

Rept. No. NSF/CEE-84041, 300 pp (Nov 1984), PB85-152155/GAR

KEY WORDS: Base isolation, Seismic design

Base isolation, an approach to seismic structural design, is discussed, and its use in the design of a community law and justice center in California is described. It was designed for an 8.3 Richter event on the San Andreas Fault, with all structural members remaining in the elastic range and all functions remaining operational after the event.

85-2244

Super Spring - A Long Period Vibration Isolator

R.L. Rinker, J.E. Faller
Joint Inst. for Lab. Astrophysics, Boulder, CO

7 pp (1984), PB85-130847/GAR

KEY WORDS: Vibration isolators

A new mechanical isolating device, called a super spring, is described. The super spring isolator makes use of the fact that a mass suspended by a long spring is effec-

tively isolated (from vibrations) for all frequencies higher than the system's natural resonance.

TIRES AND WHEELS

85-2245
Transient and Steady State Viscoelastic Rolling Contact
J. Padovan, O. Paramadilok
Univ. of Akron, Akron, OH
Computers Struc., 20 (1-3), pp 545-553 (1985), 7 figs, 1 table, 12 refs

KEY WORDS: Rolling friction, Viscoelastic properties, Contact pressure

Based on moving total lagrangian coordinates, a so-called traveling Hughes type contact strategy is developed. Employing the modified contact scheme in conjunction with a traveling finite element strategy, an overall solution methodology is developed to handle transient and steady viscoelastic rolling contact. To verify the scheme, the results of both experimental and analytical benchmarking is presented.

BLADES

85-2246
Pretwist and Shear Flexibility in the Vibrations of Turbine Blades
S. Krenk, O. Gunneskov
Riso National Lab., Roskilde, Denmark DK-4000
J. Appl. Mech., Trans. ASME, 52 (2), pp 409-415 (June 1985), 2 figs, 3 tables, 15 refs

KEY WORDS: Turbine blades, Initial deformation effects

A theory is developed for pretwisted beams with finite shear flexibility. The effect of pretwist is accounted for via the axial derivative of the St. Venant warping function. The shear flexibility relies on a decomposition of the shear stresses into torsion and shear contributions, and the normalized strain energy of the latter is expressed in terms of the shear flexibility tensor. An explicit approximation for the shear flexibility tensor is derived for cross sections of moderate wall thickness.

85-2247
Vibration of Turbomachine-Blade Due to Viscous Wakes
K. Ishihara
Kawasaki Heavy Industries, Ltd., Akashi, Japan
Flow Induced Vibrations Symp., Vol. I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 159-172, 14 figs, 2 tables, 7 refs

KEY WORDS: Rotor blades (turbomachinery), Fluid-induced excitation, Aerodynamic loads

Blade vibration due to the unsteady forces generated by the wake shed from the preceding blade row is investigated and a method is presented which can evaluate the resonant stress of the blade. The closed-loop vibration system takes into account not only the unsteady force due to the wake but also the one caused by blade vibration, as the forces acting on the blade are first analyzed by the transfer matrix method.

85-2248
Experimental Investigation of the Parallel Blade-Vortex Interaction
F.X. Caradonna, G.H. Laub, C. Tung
NASA Ames Res. Ctr., Moffett Field, CA
Rept. No. A-9850, NASA-TM-86005, 33 pp (Nov 1984), N85-13777/6/GAR

KEY WORDS: Blades, Vortex induced excitation

A scheme for investigating the parallel blade vortex interaction has been designed and tested. The scheme involves setting a vortex generator upstream of a nonlifting

rotor so that the vortex interacts with the blade at the forward azimuth. The method has revealed two propagation mechanisms: a type C shock propagation from the leading edge induced by the vortex at high tip speeds, and a rapid but continuous pressure pulse associated with the proximity of the vortex to the leading edge.

BEARINGS

85-2249
Rolling Bearing Vibrations -- The Effects of Geometrical Imperfections and Wear
C.S. Sunnersjo
SSPA Maritime Consulting AB, Box 24001, S-400 22 Goteborg, Sweden
J. Sound Vib., 98 (4), pp 455-474 (Feb 22, 1985), 14 figs, 1 table, 11 refs

KEY WORDS: Rolling contact bearings, Geometrical imperfection effects, Wear

The geometrical shape and surface properties of the components of rolling bearings will always deviate to some extent from their theoretical design. For bearings of standard tolerances these deviations are large enough to cause measurable levels of vibrations when the bearing is in operation. The purpose of this paper is to show in some detail how these surface irregularities are related to the vibration characteristics of the bearing. The study is restricted to radial bearings having a radial load and a positive clearance.

FASTENERS

85-2250
Improving Vibration Fixture Performance with Proper Fastener Interface Design
D.F. Keegan
Honeywell Avionics Div., Clearwater, FL
Test, 47 (2), pp 14-16 (Apr/May 1985), 6 figs

KEY WORDS: Fasteners, Vibration control

Vibration fixture design includes careful consideration of fixture material, fastener dimensions and resonant frequencies. The scope of this design process needs to be expanded to include the fixture-bolt interface. Force transmission, resonant frequency, and fixture life can be improved with a properly designed interface which is described.

85-2251
Toggle Mechanisms: Dynamics and Energy Dissipation
A. Mostofi
Univ. of Newcastle upon Tyne, England
Mech. Mach. Theory, 20 (2), pp 83-93 (1985), 9 figs, 8 refs

KEY WORDS: Joints, Coulomb friction

The dynamic performance of a toggle mechanism is investigated. Particular attention is given to the collapse of the toggle in the presence of Coulomb friction, and the effect of a varying periodic force on the mechanism with damped elastic coupling.

85-2252
Analysis of the Double Overlap Fatigue Specimen
J. Paul, R. Jones
Aeronautical Res. Labs., Melbourne, Australia
Rept. No. ARL-STRUC-402, 16 pp (Apr 1984), AD-A149 235/4/GAR

KEY WORDS: Joints, Fatigue life

This paper examines the behavior of the fibre and the adhesive stresses in a bonded overlap joint and shows that the results of previous one-dimensional analyses of this problem are invalid in the vicinity of the gap in the specimen. The fibre and adhesive stresses are also shown to be strongly dependent on the gap size.

STRUCTURAL COMPONENTS

VALVES

85-2253
Noise and Vibration Induced by Oscillating Supersonic Flow in a Pressure Reducing Gas Valve
M. Nakano, E. Outa, K. Tajima
Yamagata Univ., Yonezewa, Yamagata, Japan
Flow Induced Vibrations Symp., Vol. 4, Vibration Induced by Axial and Annular Flows, ASME Winter annual mtg., New Orleans, LA, Dec 9-14, 1984, pp 87-103, 15 figs, 11 refs

KEY WORDS: Valves, Fluid-induced excitation, Noise generation

Generation of intense aerodynamic noise and vibration from a high pressure gas valve might have close relation to the flow patterns particular to the valve trim geometry and the flow condition. Characteristics of acoustic modes inside a model valve and of dynamic force acting to the valve stem are investigated by experiments. Special emphasis is made to exhibit supersonic flow patterns which are essential to induce the noise and the force.

85-2254
Safety Valve Dynamic Instability: An Analysis of Chatter
G. MacLeod
MacLeod Engrg. Pty. Ltd., Blackburn, Victoria, Australia
J. Pressure Vessel Tech., Trans. ASME, 107 (2), pp 172-177 (May 1985), 4 figs, 12 refs

KEY WORDS: Valves, Chatter

Safety valve chatter, which is characterized by violent oscillation of the disk or closure member, is a dynamical phenomenon representable by differential rather than algebraic equations. It is shown that the conditions necessary for avoiding chatter may be determined from the behavior of the differential equations in the region of certain critical points. The paper demonstrates how to determine these points and establish conditions necessary for avoiding chatter.

CABLES

85-2255
Nonlinear Vibrations of Guy Cable Systems
H. Pastorel, G. Beaulieu
Institut de Recherches d'Hydro-Quebec, Varennes, Quebec, Canada J0L 2P0
Computers Struc., 21 (1/2), pp 33-50 (1985), 21 figs, 2 tables, 12 refs

KEY WORDS: Cables, Computer programs, Nonlinear response, Modal analysis, Time domain method

A nonlinear static and dynamic analysis has been performed with ADINA for the cable system of a 50-kW vertical axis wind turbine. The nonlinear static deformation and tension distribution are compared to the results of a nonlinear catenary cable model. The first natural frequencies and mode shapes, computed with ADINA, are in close agreement with experimental values obtained with the Ibrahim time domain modal analysis method.

85-2256
Dynamic and Aeroelastic Action of Guy Cables
T. Kaernae
Valtion Teknillinen Tutkimuskeskus, Espoo, Finland
Rept. No. VTTPUBL-18, ISBN-951-38-2005-X, 95 pp (1984), PB85-150506

KEY WORDS: Cables, Dynamic stiffness

Two models have been derived for the computation of the dynamic stiffness of guy cables. Both the complete mathematical model and the simplified spring-mass model can be used in a linear three-dimensional dynamic analysis of guyed masts; this is in connection with the frequency response method and a substructure technique where frequency dependent springs and dashpots are substituted for the guys. The mathe-

matical model can also be used in the design of linear guy dampers which are included in the model.

85-2257
Modelling of Submerged Cable Dynamics
J.W. Kamman, R.L. Huston
Notre Dame Univ., Notre Dame, IN 46556
Computers Struc., 20 (1-3), pp 623-629 (1985), 15 figs, 1 table, 9 refs

KEY WORDS: Cables, Submerged structures, Computer programs, Finite segment method

Results from a series of simulated submerged cable maneuvers are presented. The simulations are obtained using a three-dimensional, finite-segment model of the cable. The model, called UCIN-CABLE, consists of a series of ball-and-socket connected rigid rods. Fluid drag, inertia and buoyancy forces are included. Two types of simulation are presented: buoy release and anchor drop.

85-2258
On the Galloping Response of a Simple Aeroelastic Oscillator
A.H.P. van der Burgh
Univ. of Technology, Delft, The Netherlands
Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual mtg., New Orleans, LA, Dec 9-14, 1984, pp 37-52, 4 figs, 1 table, 11 refs

KEY WORDS: Transmission lines, Galloping, Mathematical models

A simple aeroelastic oscillator model is considered which may be used to study galloping of iced conductors. As a model a special mass-spring system in a wind-field is considered. In the one-degree-of-freedom approach, when only vertical oscillations are considered, it is shown that generalized Van der Pol equation plays a part in the description of the dynamics. In the two-degree-of-freedom approach spring and pendulum oscillations with dynamic aeroelastic interactions are considered.

85-2259
A Tensioned, Catenary-Shaped Finite Element for the Analysis of Overhead Line Conductor Galloping
T. Koutselos
Central Electricity Res. Labs., Leatherhead, UK
Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 19-35, 12 figs, 2 tables, 14 refs

KEY WORDS: Catenaries, Transmission lines, Galloping, Finite element technique, Torsional vibrations

A method is outlined for calculating the natural frequencies and mode shapes of free vibration of overhead line conductors using the finite element method. The analysis employs a new, catenary shaped, axially-loaded element. The element can model the in-plane, the out-of-plane and the torsional vibration of an overhead line conductor. It can be applied to deep or shallow catenary, single or bundled conductors, and multispan configurations.

BARS AND RODS

85-2260
Wave Propagation in a Rod with an Arbitrarily Shaped Outer Boundary and a Cylindrical Cavity of Arbitrary Shape
K. Nagaya, T. Watanabe
Gunma Univ., Kiryu, Gunma 376, Japan
J. Acoust. Soc. Amer., 77 (5), pp 1824-1833 (May 1985) 5 figs, 7 tables, 20 refs

KEY WORDS: Rods, Wave propagation, Cavity-containing media

A method is presented for solving wave propagation problems of an infinitely long bar of arbitrary cross section with an arbitrarily shaped cylindrical cavity. The boundary conditions of the inner and the outer arbitrarily shaped surfaces of the bar are satisfied by use of the Fourier expansion collocation method. The analysis derives the frequency equation for deter-

mining the phase velocities of the bar of arbitrary cross section with the cavity.

BEAMS

85-2261
Transverse Vibration and Buckling of a Cantilevered Beam with Tip Body Under Axial Acceleration
J. Storch, S. Gates
The Charles Stark Draper Lab., Inc., Cambridge, MA
J. Sound Vib., 99 (1), pp 43-52 (Mar 8, 1985) 3 figs, 1 table, 9 refs

KEY WORDS: Cantilever beams, Flexural vibration, Mass beam systems, Exact methods, Rayleigh-Ritz method

The transverse vibration and buckling of a cantilevered beam subject to constant axial acceleration with rigid tip body is investigated. Two classes of tip bodies are recognized: those with mass centers located along the beam tip tangent line, and those with mass centers having an arbitrary offset with respect to the beam attachment point (but not lying along the beam tip tangent line).

85-2262
Flexural Vibration of Axially Loaded Beams with Linear or Parabolic Taper
F.W. Williams, J.R. Banerjee
Univ. of Wales Inst. of Science and Technology, Cardiff, CF1 3EU, Wales
J. Sound Vib., 99 (1), pp 121-138 (Mar 8, 1985), 12 figs, 1 table, 21 refs

KEY WORDS: Beams, Variable cross section, Flexural vibration, Axial excitation

Curves are presented which enable the first five natural frequencies to be found for axially loaded tapered members with an important family of cross sections. Previous curves have only included axial forces in a very limited number of cases, whereas here axial forces within the range of greatest practical importance can always be allowed for.

85-2263
The Free Transverse Vibrations of Anisotropic Beams
J.L. King
Univ. of Edinburgh, Edinburgh EH9 3JL, Scotland
J. Sound Vib., 98 (4), pp 575-585 (Feb 22, 1985), 4 figs, 6 refs

KEY WORDS: Beams, Flexural vibration, Anisotropy, Bernoulli-Euler method

A uni-directional composite has high Young's modulus in the fiber direction but low shear modulus. This allows large shear strains and so invalidates some of the assumptions of engineering beam theory; in particular, the sectional loadings cannot be assumed to be related to a linear stress distribution. A theory for anisotropic materials which relates the deflection of a beam to the stress pattern is considered. This allows the calculation of corrections to the natural frequencies derived by standard beam theory.

85-2264
Vibrations of Timoshenko Beams with Elastically Restrained Ends
B.A.H. Abbas
Univ. of Basrah, Basrah, Iraq
J. Sound Vib., 97 (4), pp 541-548 (Dec 22, 1984) 7 tables, 16 refs

KEY WORDS: Beams, Elastic restraints, Timoshenko theory, Bernoulli-Euler method

The problem of free vibration of Timoshenko beams with elastically supported ends is solved, for the first time, by using a finite element model which can satisfy all the geometric and natural boundary conditions

of an elastically restrained Timoshenko beam. The effects of the translational and rotational support flexibilities on the natural frequencies of free vibrations of Timoshenko beams with non-idealized end conditions are investigated in detail.

85-2265
Predictions of Permanent Deformation of Impulsively Loaded Simply Supported Square Tube Steel Beams
R.B. Wegener, J.B. Martin
Nonlinear Structural Mechanics Res. Unit., Univ. of Cape Town
Intl. J. Mech. Sci., 27 (1/2), pp 55-69 (1985), 13 figs, 5 tables, 9 refs

KEY WORDS: Beams, Impact response

Experimental and theoretical work on model scale simply supported hollow steel beams of square tube section is described. The beams were loaded impulsively by detonating a strip of sheet explosive along the top surface, using a fairly thick layer of styrofoam to spread the effect of the explosive strip. Impulses were measured by means of a ballistic pendulum.

85-2266
Dynamic Rate Effects on Timoshenko Beam Response
T.J. Ross
Air Force Weapons Lab., Albuquerque, NM
J. Appl. Mech., Trans. ASME, 52 (2), pp 439-445 (June 1985) 9 figs, 1 table, 8 refs

KEY WORDS: Beams, Timoshenko theory, Viscoelastic properties, Strain rate, Laplace transformation

The problem of a viscoelastic Timoshenko beam subjected to a transversely applied step-loading is solved using the Laplace transform method. It is established that the support shear force is amplified more than the support bending moment for a fixed-end beam when strain rate influences are accounted for implicitly in the viscoelastic constitutive formulation.

85-2267
Impact Response of Fluid-Backed Metal Beams
S.R. Reid, S.R. Hendry
Marischal College, Univ. of Aberdeen, Aberdeen AB9 1AS, Scotland
Computers Struc., 20 (1-3), pp 321-338 (1985), 13 figs, 2 tables, 10 refs

KEY WORDS: Beams, Submerged structures, Steel, Aluminum, Impact response

A series of experiments is described in which steel and aluminium beams backed by an enclosed volume of water were subjected to central impact by V-shaped projectiles over a range of impact speeds. Their behavior is compared with that of similar beams loaded without fluid present. Transient pressure pulses in the fluid were measured. The mechanisms of collapse and the role of the fluid are discussed.

85-2268
Timoshenko Beams with Rotational End Constraints
T.J. Ross, F.S. Wong
Air Force Weapons Labs., Albuquerque, NM 87117-6008
ASCE J. Engrg. Mech., 111 (3), pp 416-430 (Mar 1985), 8 figs, 1 table, 6 refs

KEY WORDS: Beams, Timoshenko theory, Reinforced concrete

Recent experimental evidence shows that the roof elements of reinforced concrete box-like structures fail in a direct shear mode when subjected to transverse, uniformly distributed, near impulsive pressures. These failures are typically characterized by excessive shear deformations near the roof supports. The Timoshenko beam theory is applied to study the failure of these one-way slabs by assessing the impor-

tance of the shear deformations and the importance of the support constraint.

CYLINDERS

85-2269
Experiments on Flow-Induced Vibration of a Square-Section Cylinder
P.W. Bearman, I.S. Gartshore, D.J. Maull, G.V. Parkinson
Imperial College, London, UK
Flow Induced Vibrations Symp., Vol. 1, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual mtg., New Orleans, LA, Dec. 9-14, 1984, pp 85-101, 8 figs, 3 tables, 14 refs

KEY WORDS: Cylinders, Fluid-induced excitation, Galloping, Vortex-induced vibration

A long elastic body of aerodynamically bluff cross section, capable of exhibiting either galloping or vortex-induced transverse vibrations in a flow normal to its length, can, if lightly damped, also exhibit large-amplitude vibrations related to the two above forms but not predictable from information available for either form considered separately. Before a rational explanation of this behavior can be given it is necessary to have some detailed experimental evidence of the exciting forces on the body during these vibrations. Wind tunnel measurements were made on a freely-oscillating cylinder of square section under closely two-dimensional conditions in both smooth and turbulent flow.

85-2270
Flow-Induced Vibrations of Mixing Vessel Internals
R. King
BHRA, The Fluid Engrg. Ctr., Cranfield, Bedford, UK
Flow Induced Vibrations Symposium, Vol. I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 115-128, 10 figs, 12 refs

KEY WORDS: Cylinders, Fluid-induced excitation, Vortex-induced vibration, Vibration control

This paper draws together the results of research work undertaken on cylindrical members excited to oscillate by flow within unbaffled mixing vessels. Oscillations of an anchor mixer and parallel sided and stepped dip tubes are described, including those cases in which the cylinders are mounted close to the vessel wall. The results are used to define guidelines for use in calculating safe operating limits of cylinders dipping into water.

85-2271
Air-Bubble Effects on Vortex-Induced Vibrations of a Circular Cylinder
F. Hara
Science Univ. of Tokyo, Tokyo, Japan
Flow Induced Vibrations Symp., Vol. I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 103-113, 8 figs, 15 refs

KEY WORDS: Cylinders, Fluid-induced excitation, Vortex-induced vibration, Experimental data

This paper indicates, experimentally, the influence that air bubbles have in drastically reducing vortex-induced vibration and in exciting vibration of a single circular cylinder, and discusses the mechanisms involved.

85-2272
Vibrations and Flow-Induced Forces Caused by Vortex Shedding
O.M. Griffin

Naval Res. Lab., Washington, DC
Flow Induced Vibrations Symp., Vol I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 1-13, 8 figs, 2 tables, 34 refs

KEY WORDS: Fluid-induced excitation, Vortex shedding, Cylinders, Experimental data

Available data for vortex-induced lift, drag, and displacement amplitude from numerous experiments which have been conducted over the past several years is discussed. Recent measurements of the component of the overall lift force which drives the oscillations are compared with previously-reported data.

85-2273
Fluid Forces on a Rigid Cylinder in Turbulent Crossflow
T.M. Mulcahy
Argonne National Lab., Argonne, IL
Flow Induced Vibrations Symp., Vol. I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual mtg., New Orleans, LA, Dec 9-14, 1984, pp 15-28, 8 figs, 1 table, 27 refs

KEY WORDS: Cylinders, Fluid-induced excitation, Turbulence

Fluctuating lift and drag, as well as steady drag force coefficients, are presented which were obtained in water flows with Reynolds numbers in the range 3×10^4 to 2×10^5. The turbulence generated is described and the method of force measurement is outlined. Empirical bounds on the force spectra are given, and available information on spanwise correlation lengths are identified so that the data can be used to make RMS vibration response predictions where fluid-structure interaction does not occur.

85-2274
Buffeting of Isolated Tubes in Cross Flow
S.D. Savkar
General Electric Co., Schenectady, NY
Flow Induced Vibrations Symposium, Vol. I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 29-42, 15 figs, 16 refs

KEY WORDS: Cylinders, Fluid-induced excitation, Buffeting

A study of the unsteady forces induced on rigid isolated cylinders immersed in cross flows of varying levels of inflow turbulence is presented. Experimental measurements were conducted primarily in a water tunnel. An analogy is found to exist between the steady and unsteady forces induced on isolated cylinders.

85-2275
Flow-Induced Oscillations of Cylinders in the Streamwise Direction
D.H. Turnbull, I.G. Currie
Univ. of Toronto, Toronto, Ontario, Canada
Flow Induced Vibrations Symp., Vol. I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 73-84, 6 figs, 12 refs

KEY WORDS: Cylinders, Fluid-induced excitation

The purpose of the research reported here is to attempt to clarify the conditions under which in-line oscillations of a circular cylinder occur, and to establish the oscillation characteristics. A mathematical model has been developed which attempts to represent a cylinder vibrating in the streamwise direction.

85-2276
Unsteady Forces on a Cylinder in Cross Flow at Subcritical Reynolds Numbers
M.J. Moeller, P. Leehey
General Dynamics/Electric Boat, Groton, CT
Flow Induced Vibrations Symposium, Vol. I, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 57-71, 15 figs, 12 refs

KEY WORDS: Cylinders, Fluid-induced excitation, Vortex shedding, Hysteretic damping, Experimental data

The effect of large amplitude cylinder motion on the vortex shedding process was investigated using a small flush mounted force transducer. The experiments were carried out in a marine hydrodynamics laboratory's closed circuit water tunnel.

85-2277
An Experimental Study of Some of the Fundamental Aspects of Wave Induced Forces on Cylindrical Objects
W.J. Fallon
Ph.D. Thesis, Univ. of California, Berkeley, 232 pp (1984), DA8426869

KEY WORDS: Cylinders, Wave forces, Water waves, Fluid induced excitation, Offshore structures

The Morison formula, equation 2-1, forms the basis for a method widely used for predicting wave forces on offshore structures. This involves important simplifications in the flow model and, in many cases, the forces predicted by the formula vary considerably from measurements. The purpose of the present research is to examine the fundamental nature of wave-induced flow around cylinders and the resulting forces in order to advance the present knowledge of the relevant flow phenomena which, in turn, will assist future investigations toward developing an improved force prediction method.

COLUMNS

85-2278
Experimental Study of Impact-Induced Vibrations of a Simple Viscoelastic Column Model
L.X. Ren
Univ. of Lulea, S-951 87 Lulea, Sweden
J. Sound Vib., 99 (1), pp 17-27 (Mar 8, 1985), 7 figs, 1 table, 8 refs

KEY WORDS: Columns, Viscoelastic properties, Impact response, Natural frequencies

The longitudinal and transverse displacements of an almost axially impacted two-degree-of-freedom viscoelastic cantilever column model have been determined experimentally. Cases for various ratios of natural frequencies of transverse to longitudinal vibrations and for different small angles of incidence have been investigated.

85-2279
Bimodal Optimisation of a Column in an Elastic Medium, with Respect to Buckling or Vibration
A. Gajewski
Inst. of Physics, Technical Univ. of Cracow, Cracow, Poland
Intl. J. Mech. Sci., 27 (1/2), pp 45-53 (1985), 6 figs, 29 refs

KEY WORDS: Columns, Winkler Foundations, Optimization

The aim of this paper is to determine the ranges of application of unimodal and bimodal optimization techniques to the problem of a column supported by a Winkler medium. Optimization, with respect to buckling and the fundamental frequency of vibration, has been examined using both Pontryagin's and sensitivity analysis method. The characteristic diagrams of the optimal frequency or buckling load versus the lower geometrical constraint are presented.

PLATES

85-2280
Shakedown Analysis of Plates
W.A.M. Alwis, P. Grundy
National Univ. of Singapore, Kent Ridge, Singapore 0511
Intl. J. Mech. Sci., 27 (1/2), pp 71-82 (1985), 9 figs, 3 tables, 15 refs

KEY WORDS: Plates, Shakedown theorem

A numerical approach for shakedown analysis of laterally loaded elasto-plastic plates

is presented. The normal moment criterion and the Tresca criterion are considered. The analysis provides the shakedown limit and indicates the mode of failure (incremental collapse or alternating plasticity).

85-2281
Edge Vibrations in Laminated Composite Plates
S.B. Dong, K.H. Huang
Univ. of California, Los Angeles, CA 90024
J. Appl. Mech., Trans. ASME, 52 (2), pp 433-438 (June 1985), 5 figs, 16 refs

KEY WORDS: Composite plates, Layered materials, Mode shapes, Finite element technique

Plane strain edge vibrations or end modes in laminated composite plates are investigated by means of finite elements. This method is capable of modeling the behavior of any laminate construction whose properties are completely anisotropic within the plane. Two eigenvalue problems involving nonsymmetric matrices are derived.

85-2282
Continuum Plate Finite Elements for Vibration Analysis and Feedback Control of Space Lattice Structures
S.E. Lamberson, T.Y. Yang
Purdue Univ., West Lafayette, IN 47907
Computers Struc., 20 (1-3), pp 583-592 (1985), 6 figs, 4 tables, 8 refs

KEY WORDS: Spacecraft, Plates, Finite element technique, Equivalent continuum method, Modal analysis

A variety of research projects are being pursued involving the dynamic and control of large space platforms made up of lattice-type truss structures. A method involving finite element modeling of an equivalent continuum formulation based on matching the strain energy and kinetic energy is developed. The method is shown to give modal results consistent with those obtained using detailed finite element modeling of the space lattice structure, even for structures with fairly small number of repetitions of an identical unit cell.

85-2283
Use of Random Forces to Simulate the Vibroacoustic Response of a Plate Excited by a Hydrodynamic Turbulent Boundary Layer
G. Robert, J. Sabot
Ecole Centrale de Lyon, Ecully, France
Flow-Induced Vibrations Symp., Vol. 5, Turbulence-Induced Noise and Vibration of Rigid and Compliant Surfaces, ASME Winter annual meeting, New Orleans, LA, Dec 9-14, 1984, pp 53-61, 5 figs, 9 refs

KEY WORDS: Plates, Turbulence, Boundary layer excitation, Simulation, Fluid-induced excitation

A set of N random forces whose spatial location and spectral density are adjusted is proposed to simulate the wall pressure field beneath a hydrodynamic turbulent boundary layer. For a hydrodynamic turbulent boundary layer in the 2 to 10 m/s velocity range, it is shown that the vibratory response of the plate is accurately reproduced by 5 random forces over a large frequency range.

85-2284
Response of an Elastic Plate to Localized Transient Sources
N. Vasudevan, A.K. Mal
Univ. of California, Los Angeles, CA 90024
J. Appl. Mech., Trans. ASME, 52 (2), pp 356-362 (June 1985), 13 figs, 14 refs

KEY WORDS: Plates, Elastic properties, Transient excitation

The surface response of an infinite, homogeneous elastic plate to an internal dislocation across an infinitestimal area is investigated. As a companion problem, the normal displacement of the plate surface due to a time-dependent surface load is also calculated. The problems are formulated by means of a classical integral

transform in the frequency domain and the spectral response of the plate is expressed in terms of the modal contributions due to the real, imaginary, and complex roots of the Rayleigh-Lamb equation.

85-2285
Nonlinear Analysis of Layered Composite Plates and Shells
J.N. Reddy
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA
Rept. No. VPI-E-84-5, 64 pp (Jan 1984), PB85-127181/GAR

KEY WORDS: Plates, Shells, Composite structures, Finite element technique

The report contains a summary of the research conducted toward the successful completion of the project. The theoretical basis of the finite element is the following: shear deformation version of the Sanders theory for doubly-curved shells used while accounting for the large rotations of the von Karman theory and arbitrary lamination of orthotropic layers. As a special case, when the principal curvatures are set to zero, one can obtain the Mindlin shear deformation theory of laminated plates. Exact solutions of the linear theory, for certain lamination schemes and boundary conditions, were also obtained to validate the finite element solutions. The finite element program is used to analyze both static and transient behavior of plates and shells.

85-2286
Axisymmetric Vibrations of Polar Orthotropic Mindlin Annular Plates of Variable Thickness
U.S. Gupta, R. Lal
Univ. of Roorkee, Roorkee-247672, India
J. Sound Vib., 98 (4), pp 565-573 (Feb 22, 1985), 4 figs, 10 refs

KEY WORDS: Annular plates, Variable cross section, Transverse shear deformation effects, Rotatory inertia effects, Chebyshev polynomials

Analysis and numerical results are presented for the axisymmetric vibrations of polar orthotropic annular plates with linear variation in thickness, according to Mindlin's shear theory of plates. A Chebyshev collocation technique has been employed to obtain the frequency equations for the transverse motion of such plates, for three different boundary conditions. Frequencies, mode shapes and moments for the first three modes of vibration have been computed for different plate parameters.

85-2287
Axisymmetric Free Vibrations of an Annular, Circular Plate Under External Radial Tension
R. Gelos, L.B. De Natalini, P.A.A. Laura
Universidad Tecnologica Nacional, 8000 Bahia Blanca, Argentina
J. Sound Vib., 99 (1), pp 13-16 (Mar 8, 1985), 1 fig, 3 tables, 7 refs

KEY WORDS: Circular plates, Axisymmetric vibrations, Natural frequencies, Mode shapes

The title problem is tackled in the case where the in-plane state of stress is described by Lame's solution. The plate edges are elastically restrained against rotation. An approximate solution is obtained by using polynomial co-ordinate functions to represent the fundamental mode shape and employing a variational formulation to generate the frequency equation.

85-2288
Transverse Vibrations of Composite Piezoelectric Polymer Plates
D. Ricketts
Raytheon Co., Portsmouth, RI
J. Acoust. Soc. Amer., 77 (5), pp 1939-1945 (May 1985), 2 figs, 7 refs

KEY WORDS: Rectangular plates, Composite structures, Piezoelectric properties, Flexural vibrations

Free transverse vibrations of the multilayered rectangular plate are considered. The composite plate consists of 2n orthotropic

layers symmetrically located about the midplane, where the central (n and n + 1) layers are piezoelectric polymer. Using the Rayleigh method, closed formulas are obtained for the frequencies of flexural vibration. A generalized frequency expression is presented in terms of definite integrals containing the characteristic functions.

85-2289
Free Vibration of Rectangular Plates Stiffened with Viscoelastic Beams
K. Ohtomi
Toshiba Res. and Dev. Ctr., Kawasaki, Japan
J. Appl. Mech., Trans. ASME, 52 (2), pp 397-401 (June 1985), 5 figs, 4 refs

KEY WORDS: Rectangular plates, Stiffened plates, Beams, Stiffener effects

This investigation treats the free vibration of a simply supported rectangular plate, stiffened with viscoelastic beams. Using a convenient method in which the effects of beams are expressed with Dirac delta functions, the equation of motion can be expressed by only one equation. The frequency equation is obtained by applying the Laplace transformation to the equation of motion. The effects of the volume and the number of beams on the frequency and the logarithmic decrement are clarified.

85-2290
Vibration and Damping Analysis of Multilayered Rectangular Plates with Constrained Viscoelastic Layers
N. Alam, N.T. Asnani
AMU, Aligarh, India
J. Sound Vib., 97 (4), pp 597-614 (Dec 22, 1984), 6 figs, 2 tables, 13 refs

KEY WORDS: Rectangular plates, Layered materials, Material damping

Governing equations of motion for vibrations of a general multilayered plate consisting of an arbitrary number of alternate stiff and soft layers of orthotropic materials are derived by using variational principles. Extension, bending and in-plane shear deformations in stiff layers and only transverse shear deformations in soft layers are considered as in conventional sandwich structural analysis. In addition to transverse inertia, longitudinal translatory and rotary inertias are included.

85-2291
Transfer Matrix Analysis of Nonlinear Free Vibrations of Circular Plates with Variable Thickness
H. Sato, C. Shimizu
Kanazawa Univ., Kanazawa, Japan
J. Sound Vib., 97 (4), pp 587-595 (Dec 22, 1984), 7 figs, 1 table, 10 refs

KEY WORDS: Circular plates, Variable cross section, Axisymmetric vibrations, Transfer matrix method

The linear and nonlinear (large amplitude), axisymmetric free vibration of a circular plate of variable thickness, with immovable edges, is analyzed by applying the transfer matrix method. Two types of circular plate are studied: the stepped thickness plate and the continuously variable thickness plate.

85-2292
Theoretical and Experimental Investigation of the Divergence and Flutter of Drax Platen Superheaters
J. Counihan
Central Electricity Res. Labs., Leatherhead, Surrey, UK
Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter annual mtg., New Orleans, LA, Dec 9-14, 1984, pp 135-149, 14 figs, 12 refs

KEY WORDS: Platens, Heat exchangers, Flutter, Fluid-induced excitation

Fretting and eventual rupture of many of the platen superheater tubes in power station boilers led to a number of unscheduled outages. Visual observation of the platens suggested that they were being subjected to a flutter motion which is an aeroelastic

motion consisting of combined bending and torsion. To obtain a quick assessment of whether this was possible the initial flutter calculations were carried out using quasi-steady aerodynamic theory. The actual platen aerodynamics were determined from wind tunnel model tests and used with the more accurate unsteady aerodynamic theory to determine critical flutter speeds.

SHELLS

85-2293
Rapid Calculation of Mode Participation Factors for Circular Cylindrical Shells
J.W. Tedesco, C.N. Kostem, A. Kalnins
Auburn Univ., Auburn, AL
Computers Struc., 20 (1-3), pp 509-515 (1985), 8 figs, 2 tables, 14 refs

KEY WORDS: Tanks (containers), Cylindrical shells, Seismic response, Base excitation

Determination of the seismic response of circular cylindrical tanks when subjected to horizontal base excitation requires extensive computational effort. To simplify the computation of the mode participation factor of the tanks, an analytical procedure was developed and is presented herein. The base excitation is defined via spectrum technique. The shells considered in the study have a height to diameter ratio between 0.1 and 1.5, inclusive.

85-2294
Axisymmetrical Vibrations of Tanks —Analytical
M.A. Haroun, M.A. Tayel
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ASCE J. Engrg. Mech., 111 (3), pp 346-358 (Mar 1985), 7 figs, 3 tables, 9 refs

KEY WORDS: Tanks (containers), Cylindrical shells, Fluid-filled containers, Axisymmetric vibrations

An analytical method for the computation of the axisymmetrical dynamic characteristics of partly-filled cylindrical tanks is presented. The liquid is assumed to be inviscid and incompressible. The tank shell is assumed to be of constant thickness and its material to be linearly elastic. Under these assumptions, two coupled partial differential equations govern the vibrations of the shell. Because the tank is partly-filled with liquid, two different solutions are obtained for the lower (wet) and upper (dry) portions of the shell.

85-2295
Axisymmetrical Vibrations of Tanks — Numerical
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ASCE, J. Engrg. Mech., 111 (3) pp 329-345 (Mar 1985) 8 figs, 5 tables, 11 refs

KEY WORDS: Tanks (containers), Cylindrical shells, Fluid-filled containers, Axisymmetric vibrations, Numerical methods

A numerical study of the axisymmetrical dynamic characteristics of partly-filled tanks is carried out. Natural frequencies and mode shapes are evaluated by means of a discretization scheme in which the shell is modeled by finite elements and the liquid region is treated analytically. The distribution of the hydrodynamic pressure along the inner surface of the shell as well as the distribution of shell stresses are displayed.

85-2296
Dynamics and Stability of Coaxial Cylindrical Shells Conveying Viscous Fluid
M.P. Paidoussis, A.K. Misra, S.P. Chan
McGill Univ., Montreal, Quebec, Canada H3A 2K6
J. Appl. Mech., Trans. ASME, 52 (2), pp 389-396 (June 1985), 3 figs, 4 tables, 15 refs

KEY WORDS: Cylindrical shells, Concentric structures, Fluid-filled containers, Viscosity effects

The dynamics and stability characteristics of coaxial cylindrical shells containing

incompressible, viscous fluid flow are examined. Upstream pressurization of the flow (to overcome frictional pressure drop) and skin friction on the shell surfaces are taken into account, generating time-mean normal and tangential loading on the shells. Shell motions are described by Flugge's thin shell equations, suitably modified to incorporate the time-mean stress resultants arising from viscous effects.

85-2297
Free Vibration of an Oblique Circular Cylindrical Shell
T. Irie, G. Yamada, Y. Muramoto
Hokkaido Univ., Sapporo 060 Japan
J. Acoust. Soc. Amer., 77 (5) pp 1834-1839 (May 1985) 5 figs, 2 tables, 20 refs

KEY WORDS: Cylindrical shells, Circular shells, Natural frequencies, Mode shapes

An analysis is presented for the free vibration of an oblique circular cylindrical shell. For this purpose, the shell is transformed into a circular cylindrical shell of unit axial length by a transformation of variables. The deflection displacements of the transformed shell are expressed in a series of the products of the eigenfunctions of an axial beam and the trigonometric functions of angular coordinate. The dynamical energies of the shell are evaluated, and the frequency equation is derived by the Ritz method.

85-2298
The Application of the Rotating Crack Model to the Analysis of Reinforced Concrete Shells
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National Bldg. Res. Inst., Pretoria, South Africa
Computers Struc., 20 (1-3), pp 225-234 (1985), 9 figs, 21 refs

KEY WORDS: Shells, Reinforced concrete, Crack propagation, Cooling towers

The formulation of degenerated shell elements using explicit integration and a stress-resultant constitutive matrix is discussed. A formulation which produces no strain under rigid body rotations is presented. The rotating crack model for the analysis of reinforced concrete slab and shell structures is also presented. Comparisons with experimental results are included.

85-2299
Forces on the Vibrating Centrebody of an Annular Diffuser
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Flow Induced Vibrations Symp., Vol. 4, Vibration Induced by Axial and Annular Flows, ASME Winter annual mtg., New Orleans, LA, Dec 9-14, 1984, pp 41-52, 7 figs, 1 table, 7 refs

KEY WORDS: Fluid-induced excitation, Cylindrical shells, Concentric structures, Force prediction

The unsteady forces caused by the flow down an annulus formed between a fixed outer cylinder and a vibrating centerbody have been measured over a range of frequencies. It is found that the forces are particularly sensitive to the amount of pressure recovery which takes place when the annulus is terminated in annular diffuser and that high recovery leads to forces on the centerbody; these are in phase with centerbody velocity and therefore likely to lead to coupled fluid/structure self-excited vibrations.

PIPES AND TUBES

85-2300
Pipe to Pipe Impact
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Rept. No. PNL-SA-12426, CONF-840763-5, 15 pp (June 1984), DE85000368/GAR

KEY WORDS: Pipes, Impact pairs

Existing licensing criteria express what damage shall be assumed for various pipe sizes as a consequence of a postulated break in a high energy system. The purpose of the program described is to evaluate the criteria by means of a combined experimental and analytical approach. A specialized impact machine was designed and fabricated for the test program. Specimens were impacted while at PWR conditions.

85-2301
Seismic Damping Factors of Small Bore Piping as Influenced by Insulation and Support Elements
L.K. Severud, M.J. Anderson, D.A. Barta
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J. Pressure Vessel Tech., Trans. ASME, 107 (2), pp 142-147 (May 1985), 14 figs, 1 table, 9 refs

KEY WORDS: Pipelines, Nuclear reactor components, Seismic tests, Snubbers, Damping characteristics

Seismic damping tests of a prototypical liquid metal fast breeder reactor (LMFBR) small bore piping system is described, and measured transient responses to pulse excitations are reported. The test specimen was representative of a typical LMFBR insulated small bore piping system, and it was supported from a rigid test frame by prototypic dead weight supports, mechanical snubbers, and pipe clamps. Various support configurations were tested to assess the response sensitivity to insulation and other nonlinear support characteristics.

85-2302
A Procedure to Incorporate Effects of Seismic Events in a Quasi-Static Piping System Inelastic Analysis
D.F. Rotoloni, A.K. Dhalla
Atomic Power Lab., West Mifflin, PA 15122
J. Pressure Vessel Tech., Trans. ASME, 107 (2), pp 157-164 (May 1985), 8 figs, 3 tables, 7 refs

KEY WORDS: Pipelines, Nuclear reactor components, Seismic response

Inelastic analysis of a prototypic liquid metal fast breeder reactor piping system is generally performed without explicit consideration of time-dependent seismic loading. This paper presents an approximate procedure to simulate dynamic seismic loading as an equivalent static load for inelastic analysis. This procedure utilizes the results of the available linear seismic response spectrum analysis to calculate external (statically equivalent) loads.

85-2303
An Improved Mathematical Model for the Stability of Cylinder Rows Subject to Cross-Flow
S.J. Price, M.P. Paidoussis
McGill Univ., Montreal, Quebec, Canada
J. Sound Vib., 97 (4), pp 615-640 (Dec 22, 1984), 7 figs, 5 tables, 38 refs

KEY WORDS: Tube arrays, Fluid-induced excitation

Linearized, quasi-static, fluid force coefficient data obtained from wind tunnel tests are used in an analysis of the fluidelastic stability of a double row of flexible circular cylinders subject to a cross-flow. Although the analysis is quasi-static, frequency dependent terms are obtained in the aerodynamic stiffness and damping matrices. This analysis is used to investigate the effects of a number of parameters on the critical flow velocity and the theoretical results are compared with those available in the literature.

85-2304
Acoustic Resonance in Heat Exchanger Tube Banks. Second Annual Report
R.D. Blevins
GA Technolgies, Inc., San Diego, CA
Rept. No. GA-A-17779, 59 pp (Nov 1984), DE85004395/GAR

KEY WORDS: Tube arrays, Fluid induced excitation, Vortex shedding, Acoustic resonance

The fluid mechanics of acoustic resonance in heat exchanger rube bundles was studied using a wind tunnel model and an analytical model. Using the wind tunnel, the ability of coherent sound to shift the natural frequency of vortex shedding was demonstrated. Acoustic resonance due to vortex shedding from tube arrays was observed. The acoustic mode of the resonance was measured, and found to agree well with analytical predictions.

85-2305
A Simplified Finite for Added Mass and Inertial Coupling in Arrays of Cylinders
R.E. Harris, M.A. Dokainish, D.S. Weaver
McMaster Univ., Hamilton, Ontario, Canada
J. Pressure Vessel Tech., Trans. ASME, 107 (2), pp 118-125 (May 1985), 8 figs, 13 refs

KEY WORDS: Tube arrays, Fluid-induced excitation, Finite element technique

A simplified finite element has been developed for modeling the added mass and inertial coupling arising when clusters of cylinders vibrate in a quiescent fluid. The element, which is based on two-dimensional potential flow theory, directly couples two adjacent beam elements representing portions of the adjacent cylindrical structures. The primary advantage of this approach over existing methods is that it does not require the discretization of the surrounding fluid and, therefore, is computationally much more efficient.

85-2306
An Analytical Model for Vibration of Clusters of Flexible Cylinders in Turbulent Axial Flow
M.P. Paidoussis, L.R. Curling
McGill Univ., Montreal, Quebec, Canada
J. Sound Vib., 98 (4), pp 493-517 (Feb 22, 1985), 12 figs, 40 refs

KEY WORDS: Tube arrays, Fluid induced excitation

This paper describes an analytical model for the flow-induced vibration of clusters of cylinders in axial flow, in the sub-critical flow regime (i.e., at flow velocities below the threshold for fluid-elastic instabilities). The vibration is excited by the random pressure fluctuations in the turbulent flow acting on the cylinders. Correlation of the excitation field is assumed to exist, with appropriate length scales, not only on the same cylinder, but also on adjacent cylinders in the cluster.

85-2307
Vortex Shedding and Acoustic Resonance in a Staggered-Yawed Array of Tubes
S. Ziada, U. Bolleter, Y.N. Chen
Sulzer Brothers Ltd., Winterthur, Switzerland
Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 227-241, 13 figs, 16 refs

KEY WORDS: Tube arrays, Flow-induced excitation, Yaw angle, Vortex shedding, Acoustic resonance

The effect of the tube yaw relative to the incident flow on flow induced vibrations in tube banks is experimentally examined. It is shown that the yaw angle has a strong effect on damping flow excitations such as vorticity shedding, turbulent buffeting, and acoustic resonance.

85-2308
Turbulent Buffeting of Tube Arrays in Liquid Crossflow
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Babcock and Wilcox Co., Alliance, OH
Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 211-226, 14 figs, 6 refs

KEY WORDS: Tube arrays, Heat exchangers, Fluid-induced excitation, Buffeting, Turbulence

The response of heat exchanger tubes due to turbulent buffeting from the shell-side

fluid is very difficult to predict analytically. In order to make turbulence measurements in the tube bundle, it is desirable to use noninvasive methods that will not disturb the phenomenon being measured. The Laser Doppler Velocimeter is ideal for making these measurements and was chosen for these tests. The results present both the behavior of the turbulence excitation and the structural response of the tubes in the bundle as well as a state-of-the art prediction of the response.

85-2309

Buffeting of Cylindrical Arrays in Cross Flow

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 195-210, 21 figs, 9 refs

KEY WORDS: Tube arrays, Fluid-induced excitation, Buffeting

The unsteady forces induced on arrays of rigid cylinders immersed in cross flows of varying levels of inflow turbulence are discussed. It is found that the behavior of tube arrays cannot be readily gleaned by examining simple problems of interference, such as two inline cylinders. The detailed examination of cross flow induced forces on tube arrays presented here is believed to be unique. Detailed data of significance to designers of cylindrical and tube array components are presented.

85-2310

An Experimental Stability Analysis of a Single Flexible Cylinder Positioned in an Array of Rigid Cylinders and Subject to Cross-Flow

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McGill Univ., Montreal, Quebec, Canada

Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 179-194, 13 figs, 1 table, 19 refs

KEY WORDS: Heat exchangers, Tube arrays, Fluid-induced excitation, Fluid elastic instability, Experimental data

The fluidelastic response of a single flexible cylinder in an array of rigid cylinders subject to cross-flow has been investigated. Experiments were done in two wind tunnels on three different types of array. Measurements of vibration were made in both the in-flow and cross-flow directions, taking not only the vibration amplitudes, but also the power spectral density of the response over a wide frequency range and over a broad range of flow velocities.

85-2311

A Flow Visualization Study of a Square Array of Tubes in Water Cross-Flow

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 165-177, 8 figs, 20 refs

KEY WORDS: Heat exchangers, Tube arrays, Fluid-induced excitation, Photographic techniques

A flow visualization technique has been developed to study the flow behavior in tube arrays in cross-flow. The technique is used to examine flow development in a square array with a pitch ratio of 1.5. Results are presented for turbulence, vortex shedding and fluidelastic instability visualization photographs and associated frequency spectra and response curves.

85-2312

Measurement of the Destabilising Forces on a Vibrating Tube in a Fluid Cross Flow

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 151-163, 8 figs, 1 table, 7 refs

KEY WORDS: Tube arrays, Fluid-induced excitation, Force measurement, Measurement techniques

An experimental investigation has been conducted into the dynamic stability of a tube in a tube bundle with a fluid cross flow. In particular, the stability of a single flexible tube in a bundle of rigid tubes has been studied. An accurate experimental technique has been developed which enables the destabilizing fluid forces to be measured.

85-2313

Fluidelastic Instability in Shell and Tube Heat Exchangers - A Framework for a Prediction Method

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Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 103-118, 15 figs, 2 tables, 19 refs

KEY WORDS: Heat exchangers, Tube arrays, Fluid induced excitation, Prediction techniques, Fluidelastic instability

A framework for a method to predict fluidelastic instability in heat exchanger tube bundles is presented. The method relies on a computer code to obtain a simulation of the three-dimensional flow distribution within the heat exchanger. With this information, local crossflow velocities corresponding to each tube in the exchanger are obtained by interpolation and resultant crossflow velocity distributions are computed. With a knowledge of the vibration mode shapes and frequencies, reduced effective crossflow velocities are then computed for each tube.

85-2314

Dynamics of Tubes in Fluid with Tube-Baffle Interaction

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 285-304, 14 figs, 4 tables, 15 refs

KEY WORDS: Tube arrays, Fluid-induced excitation, Structure-support interaction, Plates

Three series of tests are performed to evaluate the effects of tube to tube-support-plate (TSP) clearance on tube dynamic characteristics and instability phenomena for tube arrays in crossflow. Test results show that, for relatively large clearances, tubes may possess TSP-inactive modes in which the tubes rattle inside some of the tube-support-plate holes, and that the natural frequencies of TSP-inactive modes are lower than those of TSP-active modes, in which the support plates provide knife-edge type support.

85-2315

Flow-Induced Vibration and Fluid Dynamics of Radial Bundles of Heat-Exchanger Tubes in Cross Flow

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 305-315, 8 figs, 9 refs

KEY WORDS: Tube arrays, Heat exchangers, Fluid-induced excitation, Vortex-induced vibration, Experimental data

This paper presents a study of the fluid-dynamical and vibration parameters on staggered and in-line radial bundles and on a model of a radial bundle of tubes of part of a heat exchanger in a cross flow of water and air.

85-2316

An Investigation of Open Lane Effects on Flow-Induced Vibrations in Tube Bundles for Heat Exchangers

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Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 73-86, 10 figs, 2 tables, 9 refs

KEY WORDS: Heat exchangers, Tube arrays, Fluid-induced excitation, Critical flow velocity

Open lane effects on flow-induced vibration in heat exchanger tube bundles subjected to crossflow are investigated. A rotated triangular array of tubes was tested in a wind tunnel to obtain critical velocities for uniform flow instability. A theoretical correction factor was developed predicting the critical velocities for nonuniform flow caused by open lanes. The correction factor can be multiplied by the critical velocity predictions from existing models for uniform crossflow.

85-2317
Flow-Induced Vibration of a Tube Array with an Open Lane
D.K. Johnson, W.G. Schneider
Babcock & Wilcox Co., Alliance, OH
Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 63-72, 4 figs, 3 tables, 7 refs

KEY WORDS: Heat exchangers, Tube arrays, Fluid-induced excitation, Experimental data

Open lanes often exist in heat exchanger tube arrays. This paper presents the results of an in-water test program that was used to determine velocity distributions and tube stability. Test results included the upstream and downstream flow distribution as well as the distribution across the lane and between the tubes.

85-2318
Fiver - A New Design Concept to Prevent Tube Damage From Flow-Induced Vibration in Shell-and-Tube Heat Exchangers
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Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 33-43, 10 figs, 10 refs

KEY WORDS: Heat exchangers, Fluid-induced excitation, Vibration control, Fluidelastic instability

A new design concept called Fiver, an acronym for Fluidelastic Instability Vibration Evasion Restraints, has been conceived that will extend the useful operating range for shell-and-tube heat exchangers. Flow-induced tube vibration damage can be avoided with a slight increase in the shellside pressure drop. The principle has been successfully demonstrated in isothermal experiments in an industrial-sized test exchanger using a bundle with a square tubefield layout.

85-2319
Flow-Induced Tube Vibration Thresholds in Heat Exchangers from Shellside Water Tests
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Argonne National Lab., Argonne, IL
Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 17-32, 5 figs, 5 tables, 15 refs

KEY WORDS: Heat exchangers, Fluid-induced excitation, Vibration tests, Experimental data

Typical industrial shell-and-tube heat exchanger configurations are investigated experimentally for the occurrence of potentially damaging tube vibration as a function of flowrate. The effort is part of a program to develop vibration avoidance criteria to be integrated and optimized with the advanced thermal, hydraulic, and mechanical design methods now available.

85-2320
Flows and Flow Induced Vibrations in Large Condensers

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Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 1-16, 14 figs, 3 tables, 4 refs

KEY WORDS: Tube arrays, Fluid induced excitation, Condensers

The behavior under vibration of full-scale tubes laid out in a bundle put into a test rig and subjected to cross flow of low pressure steam is examined.

85-2321
A Theoretical Model for Vibration Analysis of Cylinders in Axial Flow
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Flow Induced Vibrations Symp., Vol. 4, Vibration Induced by Axial and Annular Flows, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 105-115, 3 figs, 33 refs

KEY WORDS: Tube arrays, Fluid-induced excitation, Mathematical models

A new analytical model is proposed for the analysis of flow-induced vibration of clusters of cylinders in axial flow. In the model, cylinder vibration is assumed to be excited by random pressure fluctuations in turbulent flow. The model does not neglect hydrodynamic coupling between pressure fields on neighboring cylinders, nor does it neglect inertial and viscous inter-cylinder hydrodynamic coupling.

85-2322
Parametric and Combination Resonances of Pipes Conveying Pulsatile Fluids
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Flow Induced Vibrations Symp., Vol. 4, Vibration Induced by Axial and Annular Flows, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 117-128, 5 figs, 19 refs

KEY WORDS: Pipes, Fluid-induced excitation, Parametric resonance, Combination resonance

Velocity and pressure pulsations of flowing fluids in pipes which cause parametric and combination resonances of these pines is studied. A modification of Mettler's method regarding a straight pipe and using closed-form solutions are given for the principal regions of parametric and combination resonances.

85-2323
Steam Generator Tube/Tube Support Plate Interaction Characteristics
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Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 45-61, 14 figs, 3 tables, 11 refs

KEY WORDS: Tubes, Supports, Boilers, Fluid induced excitation, Structure-support interaction

The work performed to characterize steam generator tube-to-tube support vibration behavior over a wide range of simulated cross-flow excitation conditions is described. Several tube alignment and support clearance conditions are considered. Test results are intended as input to single-span tube autoclave wear tests, and are expected, when coupled with wear results, to enable prediction of the long term fretting behavior of steam generator tubes.

85-2324
A Rational Algorithm for Predicting Vibration-Induced Damage to Tube and Shell Heat Exchangers
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Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 87-101, 6 figs, 7 tables, 18 refs

KEY WORDS: Heat exchangers, Tubes, Fluid-induced excitation, Damage prediction

A series of calculations for the estimation of tube damage due to cross flow in shell and tube heat exchangers is presented. The algorithm explicidy treats both nonlinear interaction of the tube with a gap in a support plate and the damage induced by the subsequent impacting.

85-2325
Vibration of Tube Bundles Subjected to Two-Phase Cross-Flow
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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 251-268, 14 figs, 13 refs

KEY WORDS: Tube arrays, Flow-induced excitation, Experimental data, Damping coefficients, Fluidelastic instability

Two-phase crossflow exists in many shell-and-tube heat exchangers such as condensers, reboilers and nuclear steam generators. A comprehensive program to study tube bundle vibrations subjected to two-phase cross-flow is being conducted. The results of experiments on a normal-triangular and a normal-square tube bundle, both of p/d = 1.47, are presented.

85-2326
Experimental Study of Tube/Support Impact Forces in Multi-Span PWR Steam Generator Tubes
F. Axisa, A. Desseaux, R.J. Gibert
Centre Etudes Nucleaires Saclay, Saclay, France
Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 139-148, 14 figs, 2 tables, 11 refs

KEY WORDS: Tubes, Boilers, Interaction: structure-support, Fluid-induced excitation

The vibro-impact response of a straight part of a steam generator tube is investigated experimentally, using numerical simulation, with the aim of relating tube overall dynamics with excitation and tube-support clearance.

85-2327
Influence of Stream Turbulence Intensity and Eddy Size on the Fluctuating Pressure Forces on a Single Tube
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Chalmers Univ. of Technology, Gothenburg, Sweden
Flow Induced Vibrations Symp., Vol. 1, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 43-56, 10 figs, 23 refs

KEY WORDS: Tubes, Fluid-induced excitation, Turbulence

A systematic investigation of the influence of stream turbulence on the pressure forces on a single tube is presented. Results are presented for the mean and fluctuating pressures including spectral distributions, skewness and flatness factors of the fluctuating pressure. The rms force coefficients were estimated using the phase differences and rms pressure coefficients around the tube.

85-2328
Effects of Scale on Parameters Associated with Flow Induced Noise in Tube Arrays
J.A. Fitzpatrick, I.S. Donaldson
Trinity College, Dublin, Ireland
Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 243-250, 4 figs, 1 table, 16 refs

KEY WORDS: Tube arrays, Flow-induced excitation. Noise generation, Geometric effects, Damping coefficients

Parameters to correlate information on acoustic resonance and damping in cross

flow heat exchanger models are reviewed. The results of a series of tests to examine the effect of scale on the damping parameters are reported and a new parameter to estimate the damping capacity of a tube tank is suggested.

85-2329

Vibration of Tube Bundles Subjected to Air-Water and Steam-Water Cross Flow: Preliminary Results on Fluidelastic Instability

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 269-284, 13 figs, 11 refs

KEY WORDS: Tube arrays, Flow-induced excitation

Partial results of flow induced vibration in a square pitch tube bundle successively subjected to air-water flow and steam-water flow are presented. The most prominent vibration excitation mechanism observed was fluidelastic instability.

85-2330

On the Stability Behaviour of Heat Exchanger Tube Bundles: Part 1: Modified Theoretical Model

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 83-97, 2 figs, 36 refs

KEY WORDS: Tube arrays, Heat exchangers, Fluid-induced excitation, Fluidelastic instability

A simple theoretical model, developed from first principles for cross flow induced fluidelastic instabilities in heat exchanger tube bundles, is described. The model is an extension of the tube-in-channel physical representation which examined transverse dynamic stability of tube arrays. The theory has been modified and extended to treat static divergence as well as fluidelastic stability in both streamwise and transverse directions to the flow.

85-2331

On the Stability Behaviour of Heat Exchanger Tube Bundles: Part II: Numerical Results and Comparison with Experiments

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 99-116, 12 figs, 2 tables, 27 refs

KEY WORDS: Tube arrays, Heat exchangers, Fluid-induced excitation, Fluidelastic instability

Theoretical stability threshold curves are determined for standard heat exchanger tube bundle geometries based on a first principles model. An investigation into the sensitivity of the predicted threshold curves on variations in model parameters is also presented.

85-2332

A Semi-Potential Flow Theory for the Dynamics of Cylinder Arrays in Cross Flow

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 67-81, 4 figs, 31 refs

KEY WORDS: Tube arrays, Fluid-induced excitation, Fluidelastic instability

A semi-analytical model is presented which involves the superposition of the empirically determined cross flow about a cylinder in

an array and the analytically determined vibration-induced flow field in still fluid, for the purpose of analyzing the stability of cylinder arrays in cross flow and predicting the threshold of fluidelastic instability.

85-2333

A Theoretical Investigation of the Fluidelastic Instability of a Single Flexible Cylinder Surrounded by Rigid Cylinders

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 117-133, 7 figs, 1 table, 31 refs

KEY WORDS: Tube arrays, Fluid-induced excitation, Critical flow velocity, Damping effects, Fluidelastic instability

A quasi-static fluidelastic analysis is developed for a single flexible cylinder surrounded by rigid cylinders and subject to cross-flow. Although the analysis is quasi-static, it includes a frequency-dependent term which arises because of flow retardation around the front stagnation region of the cylinder. The combined effect of this flow retardation and of the fluid force field is to produce, for some inter-cylinder patterns of motion, a negative fluid damping, acting in the sense normal to the flow direction. Using this analysis, the effect of array pattern of the adjacent rigid cylinders is investigated.

85-2334

Self-Induced Instabilities of Parallel Tubes in Potential Cross-Flow

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Twente Univ. of Technology, Enschede, The Netherlands

Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 53-66, 7 figs, 1 table, 9 refs

KEY WORDS: Tube arrays, Fluid-induced excitation, Dynamic buckling, Flutter

A physical mathematical model based on potential flow approximation has been developed, describing the vibrational behavior of tube arrays subjected to liquid cross flow. In this model the first order effect of tube displacements is accounted for; therefore the model enables predicting critical buckling and flutter velocities.

85-2335

Classification of Flow-Induced Oscillations of Two Parallel Circular Cylinders in Various Arrangements

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Flow Induced Vibrations Symp., Vol. 2, Vibration of Arrays of Cylinders in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 1-18, 11 figs, 2 tables, 42 refs

KEY WORDS: Circular cylinders, Fluid-induced excitation, Tube arrays

A wide variety of flow-induced oscillations of two parallel circular cylinders have occurred in engineering applications. The flow interference between two cylinders, which depends on their spacing and orientation relative to the free stream, was responsible for a series of new kinds of excitation. Three categories of interference are proposed based on the available experimental data: proximity, proximity-and-wake and wake interference. Each category of interference is discussed separately with relevant excitations in terms of the reduced velocity, mass ratio, structural damping and number of degrees of freedom of two cylinders.

85-2336

Flow-Induced Vibrations of In-Line Tube Banks

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Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 163-170, 5 figs, 6 refs

KEY WORDS: Tube arrays, Fluid-induced excitation, Heat exchangers, Vortex shedding

Since the flow goes directly through the gaps of an in-line tube bank, the shedding of the vortices is controlled primarily by the jet, which is secondarily coupled with the staggered Karman-vortex arrangement. The jet is periodically disturbed by the tubes in the longitudinal direction. The main parameters for the vortex-shedding frequency are therefore the gap and longitudinal tube spacing. This theory is confirmed by experimental data.

85-2337

Overview on the Development and Implementation of Methodologies to Compute Vibration and Wear of Steam Generator Tubes

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Flow Induced Vibrations Symp., Vol. 3, Vibration in Heat Exchangers, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 149-161, 7 figs, 3 tables, 7 refs

KEY WORDS: Tubes, Fluid-induced excitation, Wear, Boilers, Nonlinear theories

Recent developments in random data measuring and analysis techniques, nonlinear finite element modeling, computer hardware and software, and wear testing techniques have been integrated into a single straightforward procedure to compute the wear history of steam generator tubes. This integrated procedure produces vibration and wear information which has been qualified against test and actual field wear and used as the basis for design. The procedure is applicable to shell and tube heat exchangers in general. This paper presents many of those key developments and provides an overview of the vibration and wear computation procedure. In addition, key concepts and parameters are highlighted.

85-2338

Dynamical Behavior of Suspended Pipe in the Sea

T. Kawashima, T. Shimogo
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Flow Induced Vibrations Symp., Vol. 1, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 145-158, 6 figs, 8 refs

KEY WORDS: Pipes, Underwater pipelines, Fluid-induced excitation, Suspended structures, Joints

The dynamic behavior of a long pipe, vertically suspended in water by a single-moored-buoy, was analyzed, and the dynamic stability of the pipe excited by a random motion of the buoy was examined theoretically.

85-2339

Leakage-Flow-Induced Vibration of a Tube-in-Tube Slip Joint

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Argonne National Lab., Argonne, IL

Flow Induced Vibrations Symp., Vol. 4, Vibration Induced by Axial and Annular Flows, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 15-24, 5 figs, 1 table, 7 refs

KEY WORDS: Tubes, Fluid-induced vibration, Slip joints, Nuclear reactor components

The susceptibility of a cantilevered tube conveying water to self-excitation by leakage flow through a slip joint is assessed experimentally. Variations of the slip joint annular gaps and engagement lengths are tested, and several mechanisms for self-excitation are described.

DUCTS

85-2340

Contributions to the Theory of Sound Propagation in Ducts with Bulk-Reacting Lining

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J. Acoust. Soc. Amer., ZZ (5), pp 1681-1685 (May 1985), 3 figs, 7 refs

KEY WORDS: Ducts, Linings, Porous materials, Sound waves, Wave propagation

A theoretical analysis of sound propagation in cylindrical ducts lined with porous material (bulk absorbers) is presented. Three configurations are discussed.

85-2341
Development of a Method of Determining the Transverse Wave Structure in a Rigid Wall Axisymmetric Duct
J.P. Pasqualini, J.M. Ville, J.F. de Belleval
Universite de Technologie, Compiegne Cedex, France
J. Acoust. Soc. Amer., ZZ (5), pp 1921-1926 (May 1985), 9 figs, 2 tables, 12 refs

KEY WORDS: Ducts, Sound waves, Wave propagation, Wave reflection

In order to decompose an acoustic field in a circular duct into radial modes, a method based upon properties and calculation of Lommel's integral is developed. To validate this method, results of amplitude and phase measurements of radial modes in a constant cross-section circular duct with hard walls are compared with a method of modal decomposition based on an axial measurement of the pressure. This technique is applied to the determination of pressure reflection coefficients of an unflanged duct.

85-2342
Annular-Flow-Induced Vibrations of an Axially Variable Body of Revolution in a Duct of Variable Cross-Section
D. Mateescu, M.P. Paidoussis
McGill Univ., Montreal, Quebec, Canada
Flow Induced Vibrations Symp., Vol. 4, Vibration Induced by Axial and Annular Flows, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 53-69, 6 figs, 18 refs

KEY WORDS: Ducts, Bodies of revolution, Variable cross section, Fluid-induced excitation, Concentric structures

An analytical investigation is presented of the unsteady flow in an axially variable, narrow annular passage and of the fluid-dynamic forces exerted on the center body, which is a flexibly mounted rigid body of revolution, with variable cross section. Based on this theory, a first approximation solution is presented, followed by a more accurate solution, for the case of unsteady ideal flow.

BUILDING COMPONENTS

85-2343
Response of a Panel Wall Subjected to Blast Loading
M.H. Klaus
NBC Defense Res and Dev. Inst., Fed. Rep. Germany
Computers Struc., 21 (1/2), pp 129-135 (1985), 10 figs, 1 table, 6 refs

KEY WORDS: Walls, Panels, Blast response, Computer programs

The response (displacements, velocities, and accelerations) of a panel wall subjected to a blast loading has been studied using three different numerical solution methods available in ADINA: modal superposition, explicit central difference, and implicit trapezoidal rule. While the displacements show excellent agreement for all three methods, the solutions for velocity and acceleration progressively diverge.

85-2344
A New Floor Response Spectrum Method for Seismic Analysis of Multiply Supported Secondary Systems
A. Asfura Facuse
Ph.D. Thesis, Univ. of California, Berkeley, 110 pp (1984), DA8426897

KEY WORDS: Floors, Seismic response, Spectrum analysis

An improved floor spectrum method for seismic analysis of linear, multi-degree-of-

freedom secondary systems multiply supported on linear, multi-degree-of-freedom primary systems is presented. The method defines and utilizes an extension of the conventional floor response spectrum.

85-2345
Modelling the Seismic Resistance of Retaining Structures
M.D. Bolton, R.S. Steedman
Cambridge Univ., Cambridge, UK
Rept. No. CUED/D-SOILS/TR-154, 8 pp (1984), PB85-146892

KEY WORDS: Retaining walls, Seismic response

New data is presented of the behavior of model walls retaining dry sand which were subjected to episodes of base shaking in the Cambridge geotechnical centrifuge. Instrumentation permits the back analysis of failures, leading to an estimate of mobilized angles of shearing in the soil. The consequences of progressive failure, both for research methodology and design practice are explored.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

85-2346
Mean Flow Effects of the Low-Wavenumber Pressure Spectrum on a Flexible Surface
A.P. Dowling
The University Engrg. Dept., Cambridge, UK
Flow Induced Vibrations Symp., Vol. 5, Turbulence-Induced Noise and Vibration of Rigid and Compliant Surfaces, ASME Winter Annual mtg., New Orleans, LA, Dec 9-14, 1984, pp 63-74, 5 figs, 7 refs

KEY WORDS: Noise generation, Fluid-induced excitation

The Lighthill theory is extended so that it may be used to determine the flow noise induced by a turbulent boundary layer over a plane homogeneous flexible surface. The influence of the surface properties and the mean flow on the sound generation is brought out explicitly through the use of a Green function. The form of the low-wavenumber wall pressure spectrum on a rigid surface with an arbitrary mean flow profile is determined. The effect of a coating layer is investigated.

85-2347
Sound Propagation Above an Inhomogeneous Impedance Plane
S.N. Chandler-Wilde, D.C. Hothersall
Univ. of Bradford, Bradford BD7 1DP, UK
J. Sound Vib., 98 (4), pp 475-491 (Feb 22, 1985), 1 fig, 1 table, 26 refs

KEY WORDS: Sound waves, Wave propagation

Boundary integral equation (BIE) methods are described for the prediction of sound propagation, in particular from a line source, over a flat plane of inhomogeneous impedance. Approximate methods, which satisfy reciprocity, for the calculation of the wave field over a two-impedance plane are proposed. These approximations, applied to propagation from a line source, give results agreeing well with those of the BIE method.

85-2348
The Radiation of a Sound Pulse from a Jet Nozzle
A.W. Bloy
Univ. of Manchester, Manchester, UK
J. Sound Vib., 99 (1), pp 95-109 (Mar 8, 1985), 18 figs, 15 refs

KEY WORDS: Jet noise, Sound waves, Wave radiation

A high amplitude sound pulse was produced in a jet pipe by injecting helium over a period of a few milliseconds. The test configuration allowed the incident and reflected waves to be isolated so that the pressure measurements in the jet pipe and in the far field could be directly compared.

85-2349
Power Spectral Density of Subsonic Jet Noise
K.B.M.Q. Zaman, J.C. Yu
NASA Langley Res. Ctr., Hampton, VA 23665
J. Sound Vib., 98 (4), pp 519-537 (Feb 22, 1985), 11 figs, 4 tables, 38 refs

KEY WORDS: Jet noise, Power spectral density

The scaling of the power spectral density (PSD) of the far field noise for subsonic, unheated, axisymmetric jets has been examined based on data obtained from the literature as well as from new experiments. It has been demonstrated that the PSD scales as the Strouhal number alone for most locations, except at shallow angles where the best scaling results with the Helmholtz number times the Doppler factor.

85-2350
Current and Current Shear Effects in the Parabolic Approximation for Underwater Sound Channels
J.S. Robertson, W.L. Siegmann, M.J. Jacobson
Rensselaer Polytechnic Inst., Troy, NY 12180-3590
J. Acoust. Soc. Amer., 77 (5), pp 1768-1780 (May 1985), 10 figs, 23 refs

KEY WORDS: Underwater sound

The effect of currents on the acoustic pressure field in an underwater sound channel is investigated. Based on fundamental fluid equations, model equations are formulated for sound pressure while including nonuniform currents in the source-receiver plane. Application of parabolic-type approximations yields a collection of parabolic equations.

85-2351
A Numerical Method for Bottom Interacting Ocean Acoustic Normal Modes
M.B. Porter, E.L. Reiss
Northwestern Univ., Evanston, IL 60201
J. Acoust. Soc. Amer., 77 (5), pp 1760-1767 (May 1985), 6 figs, 5 tables, 25 refs

KEY WORDS: Sound waves, Wave propagation, Underwater sound, Normal modes, Finite difference technique

A finite difference method is presented to numerically determine the normal modes for the sound propagation in a stratified ocean resting on a stratified elastic bottom. The compound matrix method is used for computing an impedance condition at the ocean-elastic bottom interface. The impedance condition is then incorporated as a boundary condition into the finite difference equations in the ocean, yielding an algebraic eigenvalue problem. For each fixed mesh size this eigenvalue problem is solved by a combination of efficient numerical methods. The Richardson mesh extrapolation procedure is then used to substantially increase the accuracy of the computation.

85-2352
Wave Reflection from a Sediment Layer with Depth-Dependent Properties
M. Stern, A. Bedford, H.R. Millwater
Univ. of Texas, Austin, TX 78712
J. Acoust. Soc. Amer., 77 (5), pp 1781-1788 (May 1985), 8 figs, 1 table, 34 refs

KEY WORDS: Underwater sound, Sound waves, Wave reflection

The reflection of plane acoustic waves at the water-sediment interface is analyzed. The sediments are modeled using Biot's equations with depth-dependent coefficients. Computations are made of the reflection coefficient as a function of the incident wave frequency and angle for representative sediment properties. The results are compared to those obtained by modeling the sediments as a homogeneous viscoelastic material and as a viscoelastic material with depth-dependent properties.

85-2353
Arctic Acoustic Propagation Model with Ice Scattering
D.F. Gordon, H.P. Bucker

Naval Ocean Systems Ctr., San Diego, CA Rept. No. NOSC/TR-985, 56 pp (Sept 30, 1984), AD-A149 430/1/GAR

KEY WORDS: Sound waves, Underwater sound, Wave propagation

An underwater sound propagation program has been adapted to Arctic use. The program enables computation of the coherent sound field with normal modes and the incoherent surface scattered field by integrating over ray paths from the surface to the source and receiver. For Arctic use, ice scattering and ice loss functions have been developed by comparing computed losses with Arctic propagation loss data.

SHOCK EXCITATION

85-2354
Nonlinear Dynamic Analysis of Concrete Armor Units
J.W. Tedesco, W.G. McDougal
Auburn Univ., Auburn, AL 36849
Computers Struc., 21 (1/2), pp 189-201 (1985), 11 figs, 5 tables, 33 refs

KEY WORDS: Concrete, Hydrodynamic response, Water waves

Concrete armor units are commonly employed for the protection of shorelines and rubble structures. Their design is primarily based on hydrodynamic stability, but their structural response to wave loading is poorly understood. A simple model is presented to estimate impact loads due to wave slamming on the concrete armor unit, dolos. A nonlinear dynamic analysis indicates that the units will experience a structural failure at hydrodynamically stable wave conditions.

85-2355
Dynamic Impact Over a Subsurface Crack: Applications to the Dynamic Tear Test
L.M. Brock, M. Jolles, M. Schroedl
Univ. of Kentucky, Lexington, KY
J. Appl. Mech., Trans. ASME, 52 (2), pp 287-290 (June 1985) 3 figs, 15 refs

KEY WORDS: Fracture properties, Beams, Cracked media, Impact tests

Dynamic fracture is often studied by means of the dynamic tear test, which involves transverse impact by a mass on a beam. This process generates a complicated elastic wave pattern in the beam which consists of two wave types: impact waves and reflected waves. To gain insight into the role of specific waveforms in generating the fracture at the notch end in this process, the effects of the impact waves on the dynamic notch end stress field is studied.

85-2356
Explosive Loading of Lead Hemispherical Liners
W.P. Walters, G.H. Jonas, J.A. Zukas
Ballistic Res. Lab., Aberdeen Proving Ground, MD 21005
Computers Struc., 20 (1-3), pp 615-621 (1985) 7 figs, 4 tables, 11 refs

KEY WORDS: Linings, Explosion effects

This paper documents results of a combined analytical/experimental program to study the behavior of lead hemispheres of various thicknesses subjected to explosive shock loading. Hemispherical lead liners of three different thicknesses were fabricated into aluminum confined cavity charges using OCTOL high explosive to drive the liners. Analysis of flash radiographs of the formation and jetting process indicated a gradual transition from an apparent liquid-vapor jet for the smallest wall thickness to a liquid-solid jet for the largest thickness. This apparent phase transition of the lead liners through a region of decreasing vapor lead to an analysis of the phenomena with the two-dimensional HULL code, a finite-different Eulerian code for computations of hydrodynamic and elastic-plastic phenomena.

85-2357
Influence of Directional Surface Impedance on the Low Wavenumber Pressure Spectrum
A.J. Kalinowski
Naval Underwater Systems Ctr., New London, CT
Flow Induced Vibrations Symp., Vol. 5, Turbulence-Induced Noise and Vibration of Rigid and Compliant Surfaces, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 75-100, 8 figs, 10 refs

KEY WORDS: Noise generation, Fluid-induced excitation, Noise prediction, Surface roughness

Dowling has extended the Lighthill sound analog so that the flow induced noise resulting from fluid passing over a compliant surface can be computed, by knowing the compliant surface impedance as a function of the in-plane wavenumber and frequency. The implementation of the complete theory requires, as yet, unavailable experimental information about certain turbulent source terms; consequently, results are given here in the form of a fluid pressure spectrum multiplier, rather than the actual pressure spectrum itself. Surfaces which exhibit both a magnitude and direction dependent impedance are examined and their influence on the shape of the corresponding fluid pressure spectrum multiplier is investigated.

85-2358
The Dynamics of a Harmonically Excited System Having Rigid Amplitude Constraints. Part 1: Subharmonic Motions and Local Bifurcations
S.W. Shaw
Michigan State Univ., East Lansing, MI 48824
J. Appl. Mech., Trans. ASME, 52 (2), pp 453-458 (June 1985) 6 figs, 27 refs

KEY WORDS: Harmonic excitation, Amplitude constraints, Bifurcation theory

A simple model for the response of mechanical systems having two-sided amplitude constraints is considered. The model consists of a piecewise-linear single degree-of-freedom oscillator subjected to harmonic excitation. Encounters with the constraints are modeled using a simple impact rule employing a coefficient of restitution, and excursions between the constraints are assumed to be governed by a linear equation of motion. Symmetric double-impact motions, both harmonic and subharmonic, are studied by means of a mapping that relates conditions at subsequent impacts. Stability and bifurcation analyses are carried out for these motions and regions are found in which no stable symmetric motions exist.

85-2359
The Dynamics of a Harmonically Excited System Having Rigid Amplitude Constraints. Part 2: Chaotic Motions and Global Bifurcations
S.W. Shaw
Michigan State Univ., East Lansing, MI 48824
J. Appl. Mech., Trans. ASME, 52 (2), pp 459-464 (June 1985) 8 figs, 24 refs

KEY WORDS: Harmonic excitation, Amplitude constraints, Bifurcation theory

Parameter regions are examined in which no simple stable motions exist. In such regions complicated bifurcation sequences are encountered which result in long period and chaotic motions. These motions are irregular, bounded responses to periodic excitation and have not been previously considered in systems having two-sided amplitude constraints.

85-2360
A Hemivariational Inequality Approach to the Unilateral Contact Problem and Substationarity Principles
P.D. Panagiotopoulos, A.V. Avdelas
Aristoteles Universitat, Thessaloniki, Greece
Ing. Arch., 54 (6), pp 401-412 (1984) 5 figs, 19 refs

KEY WORDS: Contact vibration

Contact problems of structures for which the contact region is not a priori known are examined. For the boundary conditions describing the contact both convex and nonconvex potential functions are considered. The first lead to variational inequalities and minimum energy principles and the second to a new type of variational forms, called hemivariational inequalities, and substationary-energy principles. Static and dynamic contact problems with friction and/or brittle fracture effects are considered.

85-2361
Analysis of Fluid-Structure Interactions. A Direct Symmetric Coupled Formulation Based on the Fluid Velocity Potential
L.G. Olson, K.-J. Bathe
Massachusetts Inst. of Technology, Cambridge, MA
Computers Struc., 21 (1/2), pp 21-32 (1985) 20 figs, 7 tables, 24 refs

KEY WORDS: Fluid-structure interaction, Finite element technique

A symmetric finite element method for solving fluid-structure interaction problems is presented. The formulation uses velocity potentials and a hydrostatic pressure as unknowns in each fluid region, and displacements as unknowns in the solid. The hydrostatic pressure is an unknown variable at only one node per fluid region. A C matrix (multiplied by time derivatives of the nodal variables, but not a damping matrix) enforces the coupling between the variables. The resulting matrix equations are banded and symmetric, making them easy to incorporate in standard displacement-based finite element codes.

85-2362
Collapse of SDOF System to Harmonic Excitation
S. Ishida, K. Morisako
Kyoto Inst. of Tech., Kyoto, Japan
ASCE J. Engrg. Mech., 111 (3), pp 431-448 (Mar 1985) 13 figs, 10 refs

KEY WORDS: Single degree of freedom systems, Wind-induced excitation, Harmonic excitation, Collapse

The investigation of the dynamic collapse behavior of structures during strong wind disturbances provides a rational foundation for estimating the safety factor of structures. In order to discuss the essential features of dynamic collapse behavior, the analytic and numerical studies are carried out on the dynamic behavior of single-degree-of-freedom inelastic systems, also taking into consideration the effect of gravity under harmonic perturbation conditions with a mean static force.

85-2363
Local Instability Characteristics and Frequency Determination of Self-Excited Wake Flows
W. Koch
DFVLR/AVA Institut f. Theoretische Stromungsmechanik, Bunsenstrasse 10, D-3400 Gottinggen, Fed. Rep. Germany
J. Sound Vib., 99 (1), pp 53-83 (Mar 8, 1985) 21 figs, 53 refs

KEY WORDS: Vortex shedding, Resonant response, Fluid-induced excitation

As suggested by the strong effect resonances and feedback mechanisms can exert upon vortices shed from blunt bodies, it is proposed that the discrete frequency, self-excited vortex shedding process itself is governed by a resonance-like mechanism. With the assumption that to a first approximation the shedding frequency is determined by the behavior in the linear regime, the resonance hypothesis is found to lead to a bifurcation condition (direct resonance condition) of the local instability eigenvalue. In a corresponding initial value formulation the same condition separates a subcritical region of locally absolute instability from a supercritical region of locally convective instability. The critical basic wake profile corresponding to the bifurcation condition is found to be near the end of the potential core.

85-2364
Torsional Stability of Nonlinear Eccentric Structures
P.K. Syamal, O.A. Pekau
Concordia Univ., Montreal, Quebec, Canada
Computers Struc., 20 (1-3), pp 293-301 (1985) 7 figs, 10 refs

KEY WORDS: Torsional response, Eccentricity, Harmonic excitation

An investigation of the occurrence of nonlinear torsional instability in singly eccentric structures with large eccentricity and subjected to translation harmonic excitation is presented. This investigation incorporates parameters defining the degree of eccentricity between the centers of stiffness and mass as well as the distribution of lateral load-resisting elements within the plan area of the eccentric structures. Torsional instability is examined in the torsional versus input frequency domain following Bolotin's stability criterion, as well as in amplitude versus frequency parameter space employing the Kryloff-Bogoliuboff method of averaging.

85-2365
Frequency/Period Estimation and Adaptive Rejection of Periodic Disturbances
D.L. Russell
Univ. of Wisconsin, Madison, WI
Rept. No. MRC-TSR-2771, 58 pp (Nov 1984) AD-A149 229/7/GAR

KEY WORDS: Active vibration control, Linear systems, Periodic excitation, Computer programs

For a wide variety of systems, including sighting devices, weapons, machine tool arms, etc., operation under conditions which involve significant oscillatory disturbances is necessary. Often it is desirable to dynamically decouple the system from the disturbances by means of the intervention of active control. In many cases this must be done without a prior knowledge of the period (equivalently, the frequency) of the incoming disturbance. This document discusses a method for suppressing the oscillations of a linear system subject to an external periodic disturbance of fixed, but unknown, period. The method entails augmentation of the original plant with a compensator and parameter identifier.

85-2366
A Method of Computation for Fluid Structure Interaction
Wing Kam Liu, Hsiu Guo Chang
Northwestern Univ., Evanston, IL
Computers Struc., 20 (1-3), pp 311-320 (1985) 6 figs, 24 refs

KEY WORDS: Fluid-structure interaction

A method of computation for fluid-structure interaction is developed. This method is especially suitable for the response calculations of both linear and nonlinear long-time duration fluid-structure interaction problems. This approach has the advantage of applying an implicit-explicit algorithm to the fluid and structural generalized displacement variables simultaneously and a modified explicit Rational Runge Kutta operator of order two applied to the pressure variables.

85-2367
Unsteady Aerodynamics Loading of an Airfoil Due to Vortices Released Intermittently from Its Upper Surface
C.Y. Chow, C.S. Chiu
Univ. of Colorado at Boulder, CO
Proc. Workshop on Unsteady Separated Flow held at the United States Air Force Academy on Aug 10-11, 1983, AD-A 148 249, pp 76-81 (1984) AD-P004 162/4/GAR

KEY WORDS: Airfoils, Vortex-induced vibration, Flow-induced excitation

An unsteady flow analysis is made of the flow past a symmetric airfoil with identical vortices released intermittently from its upper surface. The vortex train is used to simulate the flow observed in the laboratory which was perturbed by an oscillating spoiler or a rotating cam embedded in the airfoil surface.

85-2368
Unsteady Separated Flow. Forced and Common Vorticity about Oscillating Airfoils
M.C. Robinson, M.W. Luttges
Univ. of Colorado at Boulder, CO
Proc. of Workshop on Unsteady Separated Flow held at the United States Air Force Academy on Aug 10-11, 1983, AD-A148 249, pp 117-126 (1984) AD-P004 167/3/GAR

KEY WORDS: Airfoils, Fluid-induced excitation, Vortex-induced vibration, Aerodynamic loads

Flow perturbations induced through dynamic sinusoidal oscillations of an NACA 0015, NACA 0012, and flat plate were examined across a wide range of test conditions. Phase-locked multiple exposure flow visualization in conjunction with corroborative hotwire anemometry documented the development of temporally and spatially synchronous leading and trailing edge vortices induced through unsteady flow separation. Airfoil oscillation dynamics directly influenced vortex initiation, development and traversing velocities.

85-2369
Leading Edge Separation Criterion for an Oscillating Airfoil
E.C. James
Vehicle Res. Corp., Pasadena, CA
Proc. of Workshop on Unsteady Separated Flow held at the United States Air Force Academy on Aug 10-11, 1983, AD-A148 249, pp 177-183 (1984) AD-P004 175/6/GAR

KEY WORDS: Airfoils, Fluid-induced excitation, Leading edges

Unsteady flow about the well-rounded nose of a subsonic airfoil is investigated from the viewpoint of leading edge separation. The method of matched asymptotic expansions is used to develop a uniformly valid first order approximation to the inviscid flow about the airfoil's leading edge which is driven by a history-dependent term related to the airfoil's transverse motions. Applying this flow to the laminar boundary layer flow at the airfoil nose produces possibilities for a laminar boundary layer to separate.

85-2370
Theoretical Investigation of Dynamic Stall Using a Momentum Integral Method
E.J. Jumper, J.E. Hitchcock
Air Force Inst. of Tech., Wright-Patterson AFB, OH
Proc. of Workshop on Unsteady Separated Flow held at the United States Air Force Academy on Aug 10-11, 1983, AD-A148 249, pp 148-151 (1984) AD-P004 170/7/GAR

KEY WORDS: Airfoils, Wind-induced excitation

An analytical study into the gust response of an airfoil is presented. The momentum-integral equation for steady flow is extended into the airfoil that experiences a constant-rate-of-change and angle-of-attack gust. The von Karman-Pohlhausen method of integration is successfully modified to incorporate the additional transient flow terms; the equation of closure necessary to do this is also presented. Computation of the flow about a Joukowski airfoil using the new equations is performed and the results are presented and discussed.

85-2371
Navier-Stokes Calculation of the Airfoil Dynamic Stall Process
S.J. Shamroth
Scientific Res. Associates, Inc., Glastonbury, CT
Proc. of Workshop on Unsteady Separated Flow held at the United States Air Force Academy on Aug 10-11, 1983, AD-A148 249, pp 82-89 (1984) AD-P004 163/2/GAR

KEY WORDS: Airfoils, Aerodynamic loads

A time-dependent Navier-Stokes calculation procedure has been applied to the problem of an NACA 0012 airfoil oscillating in pitch in a low Mach number, high Reynolds number environment. The calculated results show many of the known physical features, including sudden suction surface separation, vortices shed at the leading and trailing edges and the return to attached flow at low incidences. Both the lift and moment coefficient curves show the expected features and the calculated wall pressure coefficients show strong correspondence to measured data.

MECHANICAL PROPERTIES

DAMPING

85-2372
Nutation Dampers and Suppression of Wind Induced Instabilities
V.J. Modi, F. Welt
Univ. of British Columbia, Vancouver, B.C., Canada
Flow Induced Vibrations Symp., Vol. 1, Excitation and Vibration of Bluff Bodies in Cross Flow, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 173-187, 13 figs, 2 tables, 2 refs

KEY WORDS: Nutation dampers, Wind-induced excitation, Vortex-induced vibration, Galloping

Performance of a set of torus-shaped nutation dampers, suitable for arresting relatively low frequency oscillations, is studied experimentally using a simple test facility. Results suggest damping characteristics to be particularly sensitive to physical properties of the liquid used, its height in the torus, damper geometry, and dynamical parameters representing amplitude and frequency.

85-2373
Determination of the Damping Properties of Structures by Transient Testing Using Zoom-FFT
D.X. Lin, R.D. Adams
Shaanxi Mechanical Engrg. Inst., Sian, China
J. Phys., E: Sci. Instrum., 18 (2), pp 161-165 (Feb 1985) 5 figs, 1 table, 15 refs

KEY WORDS: Damping coefficients, Fiber composites, Glass reinforced plastics, Fast Fourier transform, Zoom analysis method

A technique of determining the damping properties of structures is discussed. The technique is based on the transient test technique using Zoom-FFT. The principle of this technique is described and the experimental results are given of different damping level materials. A comparison is made with results obtained by more conventional methods.

FATIGUE

85-2374
A Conceptual Framework for the Interpretation of Fatigue Damage Mechanisms in Composite Materials
R. Talreja
Technical Univ. of Denmark, Lyngby, Denmark
J. Composites Tech. Res. (ASTM), 7 (1), pp 25-29 (1985) 8 figs, 27 refs

KEY WORDS: Fatigue life, Composite materials

Fatigue damage mechanisms in composite materials are briefly reviewed, giving an account of historical developments. The development of damage involves a sequence of mechanisms that may not be separable into distinct damage modes but rather into dominant damage modes. The parameters controlling growth rates of the individual mechanisms can only emerge from an understanding of the physical processes involved.

85-2375
Effects of Mean Stress on the Fatigue of Composite Materials
A. Conle, J.P. Ingall
Ford Scientific Res. Labs., P.O. Box 2053, Dearborn, MI 48121
J. Composites Tech. Res. (ASTM), 7 (1), pp 3-11 (1985) 25 figs, 2 tables, 11 refs

KEY WORDS: Fatigue life, Composite materials

A parametric stress-fatigue life relationship developed for metals has been adapted to composite material systems and validated by using data from the literature and an extensive program on XMC polyester/glass. The

employed parameter accounts for the effects of mean stress in a fatigue history and results in simplified design curves.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

85-2376
Analytical Calculation of the Mean Fatigue Life under Random Load Using the Peak Pair Method
V. Klega, J. Machek
National Res. Inst. for Machine Design, Praha-Bechovice, CSSR
Strojnicky Casopis, 36 (2), pp 155-168 (1985) 6 figs, 9 refs (In Czech)

KEY WORDS: Fatigue life, Machinery, Mechanical components

An original statistical model of fatigue life of machine parts under the random stationary gaussian loading process is given. The term of an equivalent amplitude of a random loading process is introduced and its dependence on dimensionalless parameters, describing a loading process and fatigue properties of material, is studied. A prediction procedure for mean fatigue life is proposed.

85-2377
Automatic Crack Propagation Tracking
M.S. Shephard, N.A.B. Yehia, G.S. Burd, T.J. Wiedner
Rensselaer Polytechnic Inst., Troy, NY
Computers Struc., 20 (1-3), pp 211-223 (1985) 17 figs, 19 refs

KEY WORDS: Crack propagation, Finite element technique

A finite element based approach to fully automatic crack propagation tracking is presented. The procedure presented combines fully automatic mesh generation with linear fracture mechanics techniques in a geometrically based finite element code capable of automatically tracking cracks in two-dimensional domains. Example problems are included to demonstrate the procedure.

85-2378
Measure Static Deflection to Predict Dynamic Behavior
W. Tustin
Tustin Inst. of Technology, Santa Barbara, CA
Test, 47 (2), pp 20-21 (Apr/May 1985) 4 figs

KEY WORDS: Measurement techniques, Natural frequency

This article describes a nomograph for calculating the natural frequency of a simple system from static deflection.

85-2379
Practical Requirements of Turbulent Boundary Layer Forcing Function Measurements with Wave-Vector Filters
F.E. Geib, Jr.
David W. Taylor Naval Ship R&D Ctr., Bethesda, MD
Flow Induced Vibrations Symp., Vol. 5, Turbulence-Induced Noise and Vibration of Rigid and Compliant Surfaces, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 23-37, 11 figs, 14 refs

KEY WORDS: Measurement techniques, Forcing function, Fluid-induced excitation, Turbulence, Boundary layer excitation

A discussion is presented on the use of wave-vector filters to measure the pressure fluctuations that are produced on the surface of a body by the turbulent boundary layer. Wave-vector filters allow the forcing function to be examined in spectral space as a function of wave number and frequency. The discussion presents a summary of the techniques used in wave-vector filtering, how these techniques are implemented with linear arrays of flush-mounted pressure transducers, and the effects of changing various parameters.

85-2380

An Innovative Fast Fourier Transform Array Technique for Low Wave-Number Measurements of the Turbulent Boundary Layer Fluctuating Pressure Field

T.H. Hodgson, R.F. Keltie
North Carolina State Univ., Raleigh, NC

Flow Induced Vibrations Symp., Vol. 5, Turbulence-Induced Noise and Vibration of Rigid and Compliant Surfaces, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 39-51, 12 figs, 1 table, 23 refs

KEY WORDS: Measurement technique, Fast Fourier transform, Turbulence, Boundary layer excitation

The method presented, which is a significant improvement on previous wavenumber filter methods, uses a Fast-Fourier-Transform approach in both the frequency and wavenumber domains. By use of a processed array of fifty transducers it is demonstrated that pressure spectrum measurements may be made at higher resolution than previously reported in the literature, while rejecting the convective pressure ridge by at least 60 dB and the sonic component by 30 dB. This should lead to a more accurate measurement of the all important low wavenumber plateau region of the spectrum in nearly anechoic experiments.

85-2381

An Optical Technique for Measuring the Flow-Induced Motion of a Compliant Surface

M. Gad-el-Hak
Flow Research Co., Kent, Washington

Flow Induced Vibrations Symp., Vol. 5, Turbulence-Induced Noise and Vibration of Rigid and Compliant Surfaces, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 9-22, 6 figs, 26 refs

KEY WORDS: Displacement measurement, Fluid-induced excitation, Optical methods, Measurement techniques, Lasers

The flow-induced motion of a compliant surface was measured using a novel remote optical technique. The Laser Displacement Gauge employs a Reticon camera equipped with a linear array of 256 photodiodes spaced 25 micron apart. A vertical beam of laser light produces a bright spot when it intersects the elastic or the viscoelastic compliant material, which contains minute amounts of Rhodamin-6G fluorescent dye. The axis of the photodiode array was aligned with the vertical laser beam. The digital output resulting from the continuous scanning of the array indicates the vertical displacement of the compliant surface.

85-2382

A Noncontacting Electrooptic Displacement Sensor for Piezoelectrically Driven Active Surfaces

S.A. Cerwin
Southwest Research Institute, San Antonio, TX

Flow Induced Vibrations Symp., Vol. 5, Turbulence-Induced Noise and Vibration of Rigid and Compliant Surfaces, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 1-7, 8 figs, 2 refs

KEY WORDS: Displacement measurement, Optical measuring instruments

A noncontacting electrooptic displacement sensor for the measurement of the motion of a piezoelectrically excited active wall is described. The active wall was constructed and studied to investigate the drag reduction properties of an actively driven surface in turbulent water flow. The sensor employed a two arm optical triangulation method with a two element position sensitive detector to monitor the surface displacements from a stand-off distance of 23 cm (9 inches).

85-2383

Analysis of Modal Testing Data from Incomplete Excitation

M. Rades
Polytechnic Inst., Bucharest, Romania

Rev. Roumaine Sci. Tech., Mecanique Appl., 30 (1), pp 37-47 (Jan/Feb 1985) 7 figs, 1 table, 9 refs

KEY WORDS: Modal testing, Frequency response

A procedure is suggested for analyzing incomplete rectangular frequency response matrices. Undamped natural frequencies are located by a singular value approach while tuned forcing vectors are derived using a pseudo-inverse matrix method. The technique is illustrated by its application to data from simulated tests on a lumped parameter structural model.

85-2384

XY Recording of Ultrasound Pulse-Echo Frequency Spectra in the Presence of Noise

J.S. Shell, A. Goldstein, R.J. Giesige, Jr.
Wayne State Univ., Detroit, MI 48201

Rev. Scientific Instrum., 56 (7), pp 1377-1384 (July 1985) 9 figs, 19 refs

KEY WORDS: Recording instruments, Frequency spectra

The experimental difficulties associated with recording the frequency spectra of ultrasound pulse-echo signals are discussed. The most troublesome sources of synchronous and asynchronous noise are reviewed. A simple interface circuit for XY chart recording of these frequency spectra is presented. A detailed discussion of spectral amplitude calibration procedures is also included.

85-2385

Opto-Electronic Sensor System for Multi-Component Velocity Measurements of Rotating Solid Surfaces (Optoelektronisches Sensorsystem zur mehrachsigen Geschwindigkeitsmessung rotierender fester Oberflachen)

O. Wegner, M. Horstmann
Fachbereich Elektrotechnik, Fachhochschule Bielefeld, D-4800 Bielefeld 1, Fed. Rep. Germany

Techn. Messen-TM, 52 (3), pp 106-111 (Mar 1985) 8 figs, 7 refs (In German)

KEY WORDS: Measurement techniques, Optical methods

Optical heterodyne methods for noncontact measurements of tangential, radial and angular velocity components of rotating curved rough surfaces by means of a new step-prism are described. The compact optical system functions as a self aligning transmitter and receiver of the multipath-probe-laser beams. A good optical channel separation and signal conditioning is obtained by polarization optics. The described methods are compatible with currently used modular real-time signal processing systems such as tracking processors and FFT-spectrum analyzers interfaced to micro- or process-computers.

85-2386

Time-Delay Bias Errors in Estimating Frequency Response and Coherence Functions from Windowed Samples of Continuous and Transient Signals

M.W. Trethewey, H.A. Evensen
Pennsylvania State Univ., University Park, PA

J. Sound Vib., 97 (4), pp 531-540 (Dec 22, 1984) 4 figs, 12 refs

KEY WORDS: Frequency response functions, Coherence function technique, Error analysis, Signal processing techniques

An investigation is reported of the bias effect introduced by time delays when frequency response and coherence functions are estimated from windowed time samples. The magnitude of the bias error for both functions is shown to be dependent on both the nature of the data capture window and the amount of delay. Experimental investigation verifies the derived estimates for boxcar and Hanning windows.

85-2387

The Piezoelectric Reciprocity Method for Absolute Calibration of High Frequency Vibration Standards

Ge Lifeng

Kexue Tongbao, 29 (6), pp 735-739 (1984) CSTA 530.7-84.25

KEY WORDS: Vibration probes, Calibrating

The sensitivity of vibration standard pickups is defined as the ratio of electrical output

to the mechanical input applied to a specified axis at a discrete frequency. The difficulty in calibrating lies in measuring the mechanical input, not in measuring electrical output. It is more difficult to realize reciprocity calibration of pickups at higher frequencies. This article proposes a new method. Using the reciprocity of piezoelectricity and applying the three-mass method to a piezoelectric shaker, one can determine the sensitivity of the standard pickup built into the shaker.

85-2388
Verification of Experimental Modal Modeling Using HDR (Heissdampfreaktor) Dynamic Test Data
M.G. Srinivasan, C.A. Kot, B.J. Hsieh, J.A. Dusing
Argonne National Lab., Argonne, IL
Rept. No. ANL-84-25, 102 pp (Oct 1984) NUREG-CR/4021/GAR

KEY WORDS: Modal models, Modal synthesis

An attempt to verify the reliability of the experimental modal modeling code, MODAL-PLUS, is described. MODAL-PLUS is capable of synthesizing a modal model of a structure using data from dynamic testing of a structure. The objective was to determine whether a modal model synthesized from one set of test data would be capable of correctly predicting response to a different form of excitation from a different set of data. Recorded test data from the shaker and rocket tests on the containment building of the HDR (Heissdampfreaktor) were used in the effort.

85-2389
Resonator Sensors — A Review
R.M. Langdon
GEC Res. Labs., Marconi Res. Ctr., Great Baddow, Essex, UK
J. Phys., E: Sci. Instrum., 18 (2), pp 103-115 (Feb 1985) 23 figs, 88 refs

KEY WORDS: Resonators, Reviews

Control systems are becoming increasingly dependent on digital processing and so require sensors able to provide direct digital inputs. Sensors based on time measurement, having outputs based on a frequency or phase, have an advantage over conventional analogue sensors in that their outputs can be measured directly in digital systems by pulse counting. Resonator sensors, configured to have a mechanical resonance frequency or relative phase of oscillation dependent on the measured parameter, are therefore a subject of considerable practical interest. This paper reviews the wide range of such devices which have been proposed and developed, including sensors for liquid or gas density and viscosity, liquid level, mass and mechanical force, and fluid flow rates.

DYNAMIC TESTS

85-2390
Acoustic Environment Simulation Study; Acoustic Intrusion Sensor Performance
L. Enochson, R.K. Otnes
Time Series Associates, Palo Alto, CA
67 pp (Jan 1983) AD-A149 245/3/GAR

KEY WORDS: Acoustic tests, Random vibrations, Vibration tests

A method to perform controlled acoustic tests up to a frequency of 20-25 KZH was explored. This method is based on enhancements to the method currently used to perform random vibration tests. Various methods of signal processing for acoustic intrusion sensors are explored and evaluated.

85-2391
Dynamic Testing of Thin Specimens
K.N. Safar, R.D. Adams, E.W. Bradford, D.X. Lin
Univ. of Bristol Dental School, Bristol, UK
J. Phys., E: Sci. Instrum., 18 (2), pp 118-120 (Feb 1985) 3 figs, 1 table, 15 refs

KEY WORDS: Dynamic tests, Testing techniques, Resonant bar techniques

A resonant split-bar method for the determination of the elastic moduli (Young's modulus, shear modulus and Poisson's ratio) of specimens in the form of a thin, flat disc has been developed. Measurements were made on Ivorine, a formaldehyde moulding compound which has similar moduli to human teeth, as the preliminary stage of a program on the elastic moduli of human dentine.

85-2392
The Generation of Internal Gravity Waves in a Multilayered Moving Fluid by a Flap-Type Wave Maker
M.R. Muller, P.C. Shang
Rutgers Univ., New Brunswick, NJ 08903
J. Appl. Mech., Trans. ASME, 52 (2), pp 247-252 (June 1985) 7 figs, 14 refs

KEY WORDS: Wave forces, Test facilities, Wave makers, Wave generation

Experiments have examined the waveforms generated by a flap-type wave maker in a moving, three-layer fluid. Results show that the observed modulating waveforms could be predicted accurately for low frequencies and that if the two interfaces are sufficiently close together, both mode-one waves (whose amplitude vary in the vertical such that there is only one maximum) and mode-two waves (with a vertical amplitude structure that contains two relative maxima) are generated of similar amplitude. This results in downstream shifts from sinuous to varicose modes of oscillation.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

85-2393
Use of Singular Value Decomposition for Analysis and Optimization of Mechanical System Dynamics
N.K. Mani
Ph.D. Thesis, Univ. of Iowa, 167 pp (1984) DA8428267

KEY WORDS: Numerical methods, Optimization, Computer programs, Design techniques

A computer-based method for automatic generation and efficient numerical solution of mixed differential-algebraic equations for dynamic and design sensitivity analysis of dynamic systems is developed. The equations are written in terms of a maximal set of Cartesian coordinates to facilitate general formulation of kinematic and design constraints and forcing functions. Singular value decomposition of the system Jacobian matrix generates a set of composite generalized coordinates that is well suited to represent the state of the system.

85-2394
Non-Parametric Time-Varying Spectral Estimation
A.M.M. Amin
Ph.D. Thesis, Univ. of Colorado at Boulder, 162 pp (1984), DA8428629

KEY WORDS: Power spectra, Random response, Time dependent parameters, Autocorrelation technique

The problem of estimating the time-varying power spectrum of a random process is discussed. A generalized technique for autocorrelation function estimation is introduced which allows a unified specification of a broad class of Fourier-based spectral estimators. The technique is termed the generalized lagged product window; it is employed to define specific structures for the lagged product windows which are in turn used to estimate the autocorrelation function at different lags.

85-2395
Free Vibrations of a Mono-Coupled Periodic System
M.G. Faulkner, D.P. Hong
Univ. of Alberta, Edmonton, Alberta,

Canada T6G 2G8
J. Sound Vib., 99 (1)(, pp 29-42 (Mar 8, 1985), 10 figs, 4 tables, 8 refs

KEY WORDS: Period structures, Transfer matrix method

Vibration problems of periodic systems can be analyzed efficiently by means of the transfer matrix method. The frequency equation for the whole system is shown to be obtained in terms of the eigenvalues, or their natural logarithms, which are often called propagation constants, of the transfer matrix for a single periodic subsystem. In case of a mono-coupled system this frequency equation may be solved graphically by using the propagation constant curve, thereby saving a great deal of computational effort. Two types of mono-coupled systems are considered as numerical examples: a spring-mass oscillating system and a continuous Timoshenko beam resting on regularly spaced knife-edge supports.

85-2396
Dissipativeness and Stability of a Class of Distributed Parameter Systems
M.S. Bhat, S.K. Shrivastava
Indian Inst. of Science, Bangalore 560012, India
J. Appl. Mech., Trans. ASME, 52 (2), pp 471-476 (June 1985), 24 refs

KEY WORDS: Stability, Continuous parameter method

Input-output stability of linear-distributed parameter systems of arbitrary order and type in the presence of a distributed controller is analyzed by extending the concept of dissipativeness, with certain modifications, to such systems. The approach is applicable to systems with homogeneous or homogenizable boundary conditions. It also helps in generating a Liapunov functional to assess asymptotic stability of the system.

85-2397
Tuning of Nonconservative Dynamic Systems
O. Danek
Inst. of Thermomechanics, Czechoslovak Academy of Sciences, Prague, Czechoslovakia
Strojnicky Casopis, 36 (2), pp 131-137 (1985), 9 refs (In Czech)

KEY WORDS: Eigenvalue problems, Machinery, Structural modification techniques

The relationship between the change of dynamic properties and the change of machine design parameters is studied. Dynamical properties are developed only from those eigenvalues and eigenmodes which are dominant in operating conditions. The solution is based on formulae developed from inverse eigenvalue problem.

85-2398
Formulation of Equations of Motion for Systems Subject to Constraints
C. Wampler, K. Buffinton, J. Shu-hui
Stanford Univ., Stanford, CA 94305
J. Appl. Mech., Trans. ASME, 52 (2), pp 465-470 (June 1985), 3 figs, 8 refs

KEY WORDS: Equations of motion, Constrained structures

A method for constructing equations of motion governing constrained systems is presented. The method, which is particularly useful when equation of motion have already been formulated, and new equations of motion, reflecting the presence of additional constraints are needed, allow the new equations to be written as a recombination of terms comprising the original equations. An explicit form in which the new dynamical equations may be cast for the purpose of numerical integration is developed, along with special cases that demonstrate how the procedure may be simplified in two commonly occurring situations.

MODELING TECHNIQUES

85-2399
ARMA Representation of Random Processes
E. Samaras, M. Shinozuka, A. Tsurui

Columbia Univ., New York, NY 10027
ASCE J. Engrg. Mech., 111 (3), pp 449-461 (Mar 1985) 3 figs, 34 refs

KEY WORDS: Random response, Mathematical models

Autoregressive/Moving Average (ARMA) models of the same order for AR and MA components are used for the characterization and simulation of stationary Gaussian multivariate random processes with zero mean. The coefficient matrices of the ARMA models are determined so that the simulated process will have the prescribed correlation function matrix. To accomplish this, the two-stage least squares method is used. The ARMA representation thus established permits one, in principle, to generate sample functions of infinite length and with such a speed and computational mode that even real time generations of the sample functions can be easily achieved.

85-2400
Modeling Structures for Control Design
R.E. Skelton, A. Hu
Purdue Univ., West Lafayette, IN 47907
Computers Struc., 20 (1-3), pp 303-309 (1985) 2 figs, 3 tables, 12 refs

KEY WORDS: Mathematical models, Finite element techniques, Beams

A simply supported beam is used as an example to illustrate the need for more theoretical research on the unification of the modeling and control problems of flexible structures. This paper shows that the finite element methods that focus on the convergence of modal data may not be the best approach to modeling structures for control design. Theorems for convergence of the modal costs are also presented.

PARAMETER IDENTIFICATION

85-2401
Parametric Identification of Nonlinear Dynamic Systems
A.H. Nayfeh
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061
Computers Struc., 20 (1-3), pp 487-493 (1985) 1 fig, 12 refs

KEY WORDS: Parameter identification technique, Nonlinear systems

A parametric identification technique that exploits nonlinear resonances and comparisons of the behavior of the system to be identified with those of known systems is proposed. The mathematical model is chosen in such a way that its predicted response qualitatively resembles observed responses of the physical system to chosen excitations. Experiments are proposed for the estimation of the parameters of two-degree-of-freedom systems with quadratic and cubic nonlinearities.

COMPUTER PROGRAMS

85-2402
Structural Mechanics Software: NASTRAN. 1970-1984 (Citations from the NTIS Data Base)
NTIS, Springfield, VA
248 pp (Jan 1985) PB85-853950/GAR

KEY WORDS: NASTRAN (computer program), Bibliographies, Space shuttles, Turbomachinery blades, Missiles

This bibliography contains 301 citations concerning NASA's structural analysis technology. Computer software implementation and evaluation, transient analysis of linear and nonlinear structural dynamic systems, and mathematical modeling for structural mechanics are discussed. Applications include the space shuttle, turbofan engine blades, motor component vibrations, missiles, and non-aerospace related analyses.

85-2403
SAMCR: A Two-Dimensional Dynamic Finite Element Code for the Stress Analysis of Moving Cracks

C.W. Schwartz, R. Chona, W.L. Fourney, G.R. Irwin
Oak Ridge National Lab., TN
Rept. No. ORNL/SUB/79-7778/3, 279 pp (Nov 1984) NUREG/CR3891/GAR

KEY WORDS: Computer programs, Finite element technique, Stress analysis, Crack propagation

The mathematical formulation, program structure, and details of required input data are described for SAMCR, a two-dimensional dynamic finite element code for the stress analysis of moving cracks. The code has been shown, through an extensive series of verification analyses, to perform well in modeling dynamic behavior of both uncracked and cracked structures. In particular, the code has been demonstrated to provide useful information regarding run-arrest events in polymeric laboratory samples and large thermally shocked steel cylinders.

85-2404
Dynamic Response Simplified Models for Global Analysis. DYSFRA - A Computer Program for Dynamic and Static Nonlinear Analysis of Space Frame Structures
J. Amdahl, N.T. Nordsve
Norges Tekniske Hoegskole, Trondheim, Norway
Rept. No. STF71-A84018, ISBN-85-595-3459-2, 42 pp (May 19, 1984) PB85-123982/GAR

KEY WORDS: Computer programs, Finite element technique, Beams, Frames

A brief description of a finite element program (DYSFRA) intended for static and dynamic analysis of space frames is presented. The formulation allows for large displacements and nonlinear material behavior is accounted for by introduction of yield hinges. The yield criterion is formulated in terms of stress resultants. The potential of the method is with respect to accuracy and efficiency demonstrated in case studies of simple beam elements and a plane frame structure.

85-2405
Prediction of Dynamic Stall Characteristics Using Advanced Non-Linear Panel Methods
B. Maskew, F.A. Dvorak
Analytical Methods, Inc., Redmond, WA
Rept. No. AMI-8406, AFOSR-TR-84-975, 63 pp (Apr 4, 1984) AD-A148 453/4/GAR

KEY WORDS: Computer programs, Boundary layer excitation

A surface singularity panel method was extended for modeling the dynamic interaction between a separated wake and a surface undergoing an unsteady motion. The method combines the capabilities of an unsteady, time-stepping code and a technique for modeling extensive separation using free vortex sheets. Routines were developed for treating the dynamic interaction between the separated wake and the solid boundary in an environment where the separation point is moving with time.

85-2406
A Finite Element Code for the Computation of the Dynamic Response of Structures Involving Contact Effects
D. Osmont
Office National d'Etudes et de Recherches Aerospatiales, BP 72-92322 Chatillon Cedex, France
Computers Struc., 20 (1-3), pp 555-561 (1985) 16 figs, 12 refs

KEY WORDS: Computer programs, Finite element technique, Hertzian contact

A finite element code for computing the dynamic response of structures involving contact effects is presented. The code was developed on a UNIVAC 1180 computer in a modular and structured way. All the core memory management is done by a core memory manager, which also acts as a local database manager. Applications to the dynamic Hertz problem are presented.

AUTHOR INDEX

CALENDAR

1985

DECEMBER

11-13 Western Design Engineering Show [ASME] Anaheim, CA (ASME)

1986

JANUARY

28-30 Reliability and Maintainability Symposium [ASME] Las Vegas, NV (ASME)

FEBRUARY

3-6 4th International Modal Analysis Conference [Union College] Los Angeles, CA (Ms. Rae D'Amelio, Union College, Wells House, Schenectady, NY 12308 - (518) 370-6288)

MARCH

5-7 Vibration Damping Workshop II [Flight Dynamics Laboratory of the Air Force Wright Aeronautical Labs.] Las Vegas, NV (Mrs. Melissa Arrajj, Administrative Chairman, Martin Marietta Denver Aerospace, P.O. Box 179, Mail Stop M0486, Denver, CO 80201 - (303) 977-8721)

24-27 Design Engineering Conference and Show [ASME] Chicago, IL (ASME)

APRIL

8-11 International Conference on Acoustics, Speech, and Signal Processing [Acoustical Society of Japan, IEEE ASSP Society, and Institute of Electronics and Communication Engineers of Japan] Tokyo, Japan (Hiroya Fujisaki, EE Department, Faculty of Engineering, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan)

13-16 American Power Conference [ASME] Chicago, IL (ASME)

29-1 9th International Symposium on Ballistics [Royal Armament Research and Development Establishment] RMCS, Shrivenham, Wiltshire, UK (Mr. N. Griffiths, OBE, Head/XT Group, RARDE, Fort Halstead, Sevenoaks, Kent TN14 7BP, England)

MAY

12-16 Acoustical Society of America, Spring Meeting [ASA] Cleveland, OH (ASA Hqs.)

JUNE

3-6 Symposium and Exhibit on Noise Control [Hungarian Optical, Acoustical, and Cinematographic Society; National Environmental Protection Authority of Hungary] Szeged, Hungary (Mrs. Ildiko Baba, OPAKFI, Anker koz 1, 1061 Budapest, Hungary)

4-6 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] Las Vegas, NV (Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)

8-12 Symposium on Dynamic Behavior of Composite Materials, Components and Structures [Society for Experimental Mechanics] New Orleans, LA (R.F. Gibson, Mech. Engrg. Dept., University of Idaho, Moscow, ID 83843 - (208) 885-7432)

JULY

20-24 International Computers in Engineering Conference and Exhibition [ASME] Chicago, IL (ASME)

21-23 INTER-NOISE 86 [Institute of Noise Control Engineering] Cambridge, MA (Professor Richard H. Lyon, Chairman, INTER-NOISE 86, INTER-NOISE 86 Secretariat, MIT Special Events Office, Room 7-111, Cambridge, MA 02139)

24-31 12th International Congress on Acoustics, Toronto, Canada (12th ICA Secretariat, P.O. Box 123, Station Q, Toronto, Ontario, Canada M4T 2L7)

SEPTEMBER

14-17 International Conference on Rotordynamics [IFToMM and Japan Society of Mechanical Engineers] Tokyo, Japan (Japan Society of Mechanical Engineers, Sanshin Hokusei Bldg., 4-9, Yoyogi 2-chome, Shibuyak-ku, Tokyo, Japan)

22-25 World Congress on Computational Mechanics [International Association of Computational Mechanics] Austin, Texas (WCCM/TICOM, The University of Texas at Austin, Austin, TX 78712)

OCTOBER

5-8 Design Automation Conference [ASME] Columbus, OH (ASME)

5-8 Mechanisms Conference [ASME] Columbus, OH (ASME)

19-23 Power Generation Conference [ASME] Portland, OR (ASME)

20-22 Lubrication Conference [ASME] Pittsburgh, PA (ASME)

NOVEMBER

30-5 American Society of Mechanical Engineers, Winter Annual Meeting [ASME] San Francisco, CA (ASME)

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AHS American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA American Institute of Aeronautics and Astronautics
1633 Broadway
New York, NY 10019

ASA Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE American Society of Civil Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASLE American Society of Lubrication Engineers
838 Busse Highway
Park Ridge, IL 60068

ASME American Society of Mechanical Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASTM American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

ICF International Congress on Fracture
Tohoku University
Sendai, Japan

IEEE Institute of Electrical and Electronics Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

IES Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IMechE Institution of Mechanical Engineers
1 Birdcage Walk, Westminster
London SW1, UK

IFToMM International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA Instrument Society of America
67 Alexander Dr.
Research Triangle Pk., NC 27709

SAE Society of Automotive Engineers
400 Commonwealth Dr.
Warrendale, PA 15096

SEE Society of Environmental Engineers
Owles Hall, Buntingford, Hertz.
SG9 9PL, England

SESA Society for Experimental Mechanics (formerly Society for Experimental Stress Analysis)
14 Fairfield Dr.
Brookfield Center, CT 06805

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SVIC Shock and Vibration Information Center
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PUBLICATION POLICY

Unsolicited articles are accepted for publication in the **Shock and Vibration Digest.** Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in **Digest** articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the following example:

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and practical applications that have been explored [3-7] indicate . . .

The format and style for the list of References at the end of the article are as follows:

- -- each citation number as it appears in text (not in alphabetical order)
- -- last name of author/editor followed by initials or first name
- -- titles of articles within quotations, titles of books underlined
- -- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- -- volume, issue number, and pages for journals; publisher for books
- -- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter -- A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).

2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).

3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Dev. (1962).

Articles for the **Digest** will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the **Digest.** Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 3000 to 4000 words in length. For additional information on topics and editorial policies, please contact:

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